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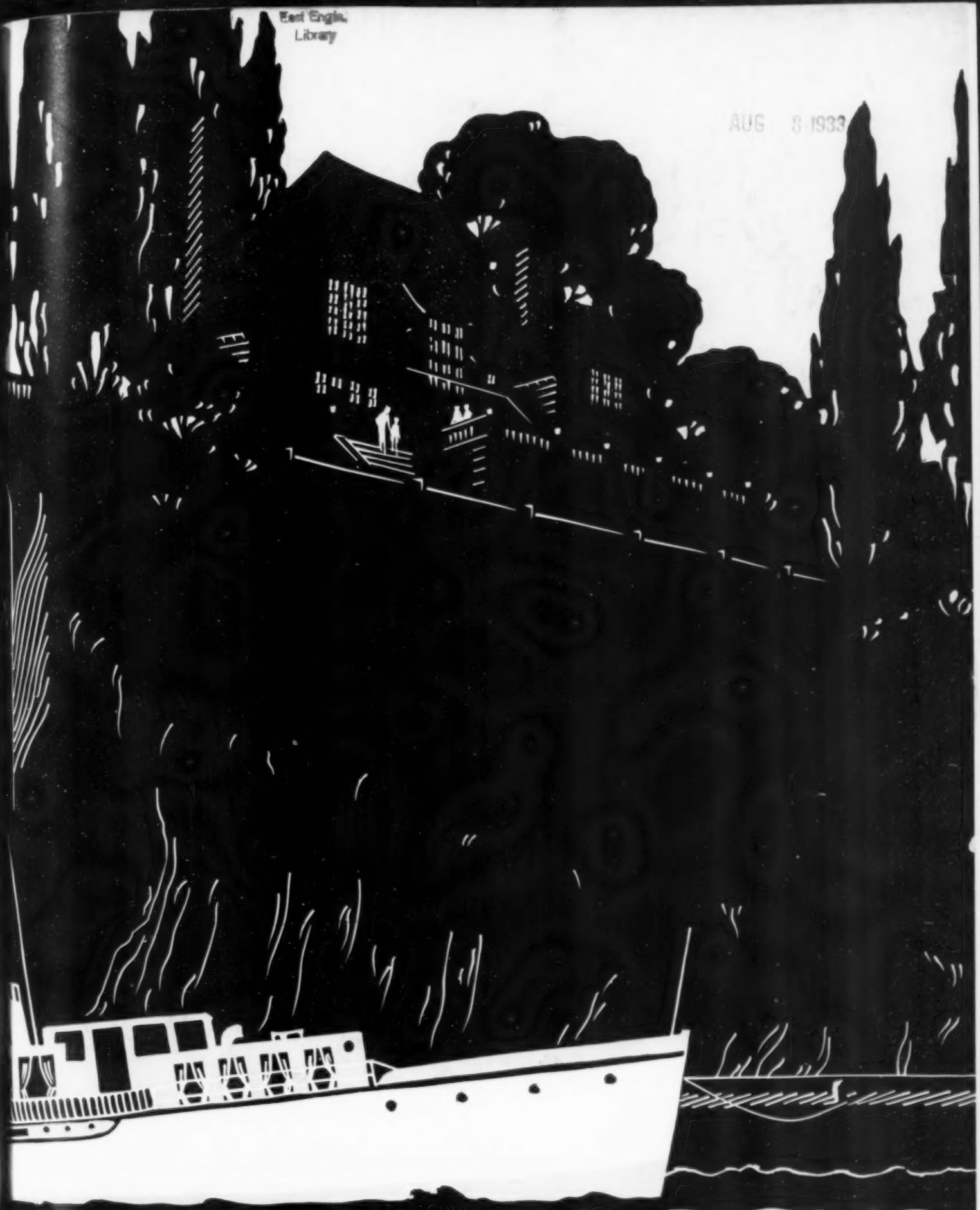

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Metal Progress

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Ernest E. Thum, Editor

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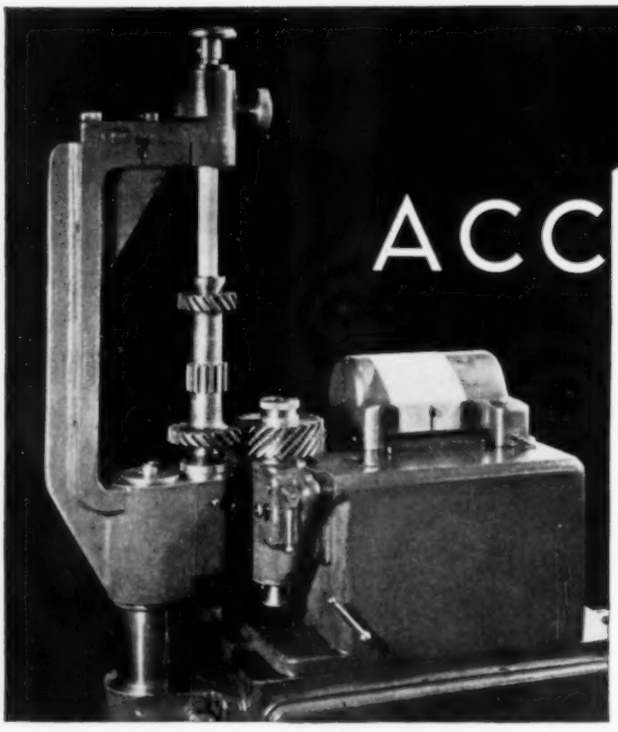

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Campers no Longer Need to Burn Their Meat and Pone on Forked Sticks and Flat Rocks, What With Modern Gasoline Stoves and Patent Grids and Grills

Metal Aids the Sportsman and Camper

By J. G. MAPES
Managing Editor
The A.S.S.T. *Review*

JOHN Q. METALLURGIST, LONG A MEMber of the Chicago Chapter of the American Society for Steel Treating, once noticed in the published minutes of a meeting of his Society's directors a resolution urging everyone to make a personal effort to increase the use of metal. At the time of reading John thought this an excellent idea, but he had little opportunity to follow the suggestion until vacation time rolled around.

Now John was a man who liked to spend his vacation as far away from the din of a forge shop and the sizzle of a quench as he could get. The children were in good hands for the summer, so John and Mrs. John planned a camping and fishing trip and resolved to use metal equipment wherever possible. Fortunately there is available in Chicago a firm, second to none, making and retailing sporting and camping goods (Von Lengerke & Antoine). Here to their surprise, they found that metal really played an important role in sporting goods. They were of course familiar with steel shafted golf clubs and metal tennis rackets with woven steel strings, but they were not prepared to find steel, aluminum, brass, and copper used so frequently in camping and fishing equipment.

First they bought an all-metal boat, as light as one of wood, welded rather than screwed together, and much less likely to leak. John was pleased to note that this purchase represented more than 100 sq.ft. of fine sheet steel, and yet the price compared favorably to a wooden boat.

"Why Row?"

"Why row?" asked John as he investigated outboard motors. The selection here was wide. Costs ran from $75 to as much as $400, the number of cylinders from one to four, and the brake horse power from 1.4 up to 25. The motor he selected was a 2-cylinder, 4-hp. motor weighing 46 lb. and costing less than $125. This had power enough to push John, Mrs. John, and their boat along at an easy six miles per hour.

Most of this engine was made of non-ferrous metals, the propeller shaft and the cylinder block representing most of the iron and steel in the motor. Aluminum was used for the flywheel and magneto housing, gas tank, rudder, propeller shaft housing, and pistons. Bronze was the metal in gears, propeller, and generally for the bolts, screws and small fittings in the underwater parts. Small zinc die castings, perhaps 2 or 3 lb. of them, found various purposes.

Transportation problems being settled, suitable shelter had next to be provided. What John really wanted was a lean-to made of very thin sheet aluminum hung on a folding duralumin frame, but, unfortunately for our hero's metal-consuming ambitions, canvas was the only tenting material available. He could get steel tent pins though, made of rustproofed angle iron and weighing only 1½ lb. per dozen, but decided that they could easily be chopped from a tree-branch on the camp site. However the tent he chose had a steel center frame like the ribs of an umbrella which rested on tele-

scoping steel tubes driven into the ground at the four corners of the tent.

John was then ready to head for the rod and reel department when Mrs. John checked him by asking what he expected her to cook in. John evidently had taken that end of it as a matter of course, but he attempted a brilliant recovery by asking what was the matter with the kitchen stuff at home. One look from Mrs. John, and he trotted meekly along while the salesman and Mrs. John discussed the relative advantages of heavy cast iron and light aluminum for frying pans.

What they finally chose was a set of aluminum utensils designed to nest inside the largest pot, which was 9½ in. in diameter and 8¾ in. deep. Two cooking pots, a coffee pot, frying pan, 2 plates, 2 cups, 2 soup bowls, and 2 each of knives, forks, dessert spoons, and teaspoons! All in a package and weighing less than 6½ lb.

A slight disagreement arose between Mr. and Mrs. John on the subject of stoves. John, all for the primitive, wanted a wood fire under a grid. Mrs. John, who had the work to do, held out for a gasoline stove. This argument ended in a draw. Mrs. John got her stove, a two-burner size with built-in oven, and John got his grid, made from flat wire, spot welded and tin plated. The stove frame was built of light angle iron with a grate of heavy wire. Oven walls were thin enameled sheets. Burners were concentric cylinders of perforated sheet. To avoid all scaling at red hot operating temperatures they were made of heat resisting 25% chromium-iron alloy. (Such a burner, in case you don't know, has revolutionized the oil stove industry in the last two or three years.)

Fishing Rods, Solid or Hollow

When these transactions were closed John broke for the rods and reels. He had not done much fishing since he was a boy and he was amazed at the many rods he could choose from. He immediately eliminated all but the steel rods although he admired the workmanship in the featherweight split bamboos.

He was told that tremendous advances had been made in rod manufacture in the last few years. The first steel rods were made of narrow strip rolled into tubes and crimped together, but these were not very successful because they lacked sufficient strength and "whip." The newest hollow rods are seamless tubes or, in the less expensive line, welded tubes. They range from 4½ to 9 ft. long depending on the type. All are jointed; each 12-in. section from handle to tip has progressively smaller diameter.

The hollow tube steel rods are about equal in weight to split bamboo rods of similar size and purpose and are well thought of by fishing enthusiasts, according to the salesman. Enamel finish is generally used, both to prevent rust and to provide an attractive appearance. Some rod handles have bands of nickel silver to fasten on the reels, but in many models these bands are chromium plated brass.

In addition to the hollow rods, which are made in both round and hexagonal cross-section, a solid steel rod has been developed for heavy fighting fish such as the muskellunge. These rods are cold drawn and swaged into tapering square sections and are cadmium plated. A chrome-vanadium alloy steel is the choice of one maker of this type rod.

Poor John was taken aback by the hundreds of rods displayed, but he was wise enough to let someone who knew fishing select his rods for him. Two steel rods were added to the invoice, one combination bait or fly rod for John and one for Mrs. John, and, because he couldn't resist the sales appeal of alloy steel, a third "musky" rod. An aluminum case large enough for his three rods was recommended which John gladly took, and it represented a full pound of aluminum sheet.

In the matter of reels, John was somewhat shocked to learn that he could spend as much as $150 or as little as 75c. Here again he did not trust his judgment, so he was advised to select a low-priced all-purpose reel which would be adaptable for any type of fishing he would be likely to do. Except for a pair of tiny heat treated steel pivots, the entire reel was made of non-ferrous metal. The pivot bearings, spool, and gear train were phosphor bronze and the frame was nickel silver. A more expensive reel which John did not buy had an aluminum frame. Other reels used chromium plated brass as frame material.

Fishing lines made of the copper alloys

John learned, found use in deep waters where a silk or cotton line was too light to sink without "bellying" widely before the current. Bronze wire, twisted or braided, weighs surprisingly little when made into fishing line — only 5¼ oz. in 50 yards. The braided wire, though slightly more expensive, was recommended for its freedom from kinking and its great pliability, which permit it to be used on an ordinary reel.

Fish hooks, it seems, are no longer laboriously cut and bent by hand, although some of the old masters' names are preserved in the modern products of the machine. They appeared to be made of spring steel, as they were moderately stiff and were hard enough to scratch the cylinder block of John's outboard motor. A few were copper plated and others were colored dark, presumably as much to prevent gleam as to prevent rust.

The craftsman's skill is still evident in the making of flies. John thought it would be some time before a machine could be designed to attach the gaudy wisps of hair and feathers which conceal the hook and fool the trout and bass. Other lures imitate every variety of fish food from mice and frogs to worms and crabs. Most of these are made of wood or cork, but one hollow minnow, weighing only 1 64 of an ounce, was made of duralumin, and no more expensive than a similar lure made of wood.

Cooking Pot, Pail, Coffee Pot, Skillet, and Table Equipment for Two All Nest Together. When made of aluminum the outfit weighs less than 7 pounds

Spoons and spinners were made of copper and nickel plated or enameled to catch the eye of bass and pickerel. Some of these were elaborately shaped over mandrels before plating or enameling. One spoon that he saw was plated with nothing less than gold. The more expensive spoons and spinners were fastened to piano wire treated to resist corrosion.

Sinkers were, of course, made of lead, although some types were cast around brass

swivels or snaps. (Aluminum casting-weights from $\frac{1}{4}$ to $\frac{1}{2}$ oz. are used as standards by casting clubs when members are competing in accuracy or distance matches.)

Iron, Aluminum, Copper, Zinc

As John examined the thousands of flies and lures before him, he reacted to their brilliance as a fish should, to the end that when he left that department he had accumulated quite a collection. This meant that handling and carrying his tackle had come to be a problem which could best be solved by a certain aluminum tackle box, and when this had been added to his purchases his stock of aluminum was increased by $5\frac{1}{2}$ lb.

By this time John had accumulated nearly all the equipment he could possibly need. (Mrs. John thought both privately and publicly that he was spending too much money and anyway it wasn't her way of going shopping.) As they were leaving, however, he saw a few little items he wanted. There was a 12-in. brass chain, nickel plated, for stringing the fish he was going to catch. (Mrs. John snorted audibly.) There was also a brass scale for weighing the big ones and a little galvanized scraper for cleaning them.

One more thought struck John as he left the store. How about one of those sheet steel refrigerator baskets — ideal for carrying a few bottles of beer and keeping the cream cold? At this point both Mrs. John and the patient salesman explained gently that there was no ice where he was going, and before he knew what had happened he was out of the door and on his way home.

There is no moral to this little tale except that metal is invading many a line once exclusively held by non-metals, and that as more uses are found for metals, not only will the metal industries in general benefit, but also the men in those industries. In other words, John Q. Metallurgist was doing himself a good turn when he bought as much metal camping and fishing goods as possible.

As nearly as can be figured out, his equipment including boat and motor cost him about $425, and amounted to about 300 lb. of metal, divided approximately as follows: Iron and steel 235 lb., aluminum 50 lb., copper and copper alloys 6 lb., and other metals 4 lb.

Metal Fishing Kits — Hook, Line and Sinker — All Testify to the Adaptability of Metal and Skill of the Metal Craftsman

Bright Annealing Coils of Strip in Mass Production

SIMPLICITY OF EQUIPMENT AND operation is an outstanding feature in the strip annealing department of the Cuyahoga Works, American Steel & Wire Co., Cleveland, where coiled strip steel is bright annealed in a battery of electric furnaces.

These furnaces are of the bell type, and are arranged in two double rows, six furnace bases in a row, the double rows separated by platforms. The furnace proper is movable and is enclosed in a cylinder of $\frac{3}{16}$-in. steel plate, open at the bottom and closed at the top. This inverted steel tank is lined with insulation and refractory material and the inner surface is covered with hairpin resistor units. The bracing on top the cylinder overhangs and forms a lifting fixture. The bottom of the shell is flanged inward to support the insulation.

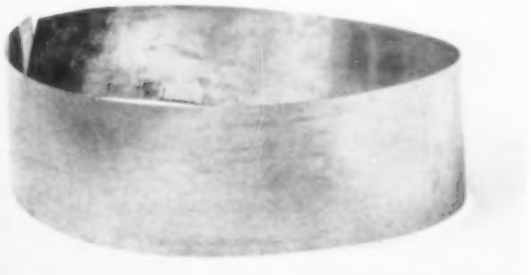
As is seen in the view on page 20, the coils of strip (all of about equal internal and external diameter) are stacked on the base in an orderly manner. This forms a large cavity down the center of the stack, which also is utilized for heating. In other words, additional heating elements are suspended from the top of the casing down through the center of the coils. Of course, this results in quicker and more uniform heating throughout the coils.

It is estimated that about two-thirds of the heat comes from the elements around the inner walls of the furnace bell, and the center unit provides one-third. Both sets of units are of nickel-chromium strip, those in the center being wound around rods of heat resisting steel. Electrical capacity of each of these furnaces is from 90 to 100 kw.

A second essential portion of each furnace is a base — or rather a series of bases mounted on wheels, for each heating cover is used in succession on one base after another. These bases run on tracks in a shallow pit 60 ft. long and a little more than 15 ft. wide, so that two tracks can be laid side by side in each pit. Tops of the bases are approximately at floor level. In construction, these bases are round in plan, the very edge being a trough for a seal (to be described later). Inside the seal is a smooth brick platform at the exact center of which is a round pier, three courses high, of proper diameter for a fairly snug fit inside the shell or bell. On top this pier is a grillage of heat resistant castings, to carry the load of strip. This entire structure is placed on a square carbody having lifting-eyes at the corners.

A third essential element is a gas-tight cylindrical cover which encloses the stack of strip, and separates it from the heating elements. Its diameter and height are such that it just clears the electric resistors on the inside

A Piece of Bright Annealed Strip Has no Sign of Heat Tints at the Edges



of the furnace. It is closed on top except for an inner cylinder 15 in. diameter which fits within the inside diameter of the stack of coils and is the receptacle for the central heating unit of the furnace.

A wide, flat base rests on the furnace base, and a deep flange forms a sealing ring. This sealing ring dips into the circular trench in the top of the base, which contains heavy oil as a seal. Welded 18-8 plate, 16-gage, manufactured by other subsidiaries of the U. S. Steel Corp., is used for this cover.

One base will accommodate a charge of coils as heavy as 6 tons, although 2½ tons is the usual load. Minimum inside diameter of the coils is 16 in.; maximum outside diameter is 35 in.; the height of the stack of coils cannot exceed 56 in.

To start operation, an empty base is stacked with coils from the cold strip mill and the 18-8 cover lowered in place. Hose connections are then made to pipes built into the base and the air inside the cover is displaced with clean, dry gas of proper composition. Then a hot furnace bell is placed over the freshly loaded base and cover, and the electric current is properly controlled for the required heating and holding cycle. At the end of that time, the furnace bell — without cooling — is transferred to the next oncoming load on the same track, and the hot load of strip then cools (still inside the 18-8 cover and in a controlled atmosphere) by natural radiation.

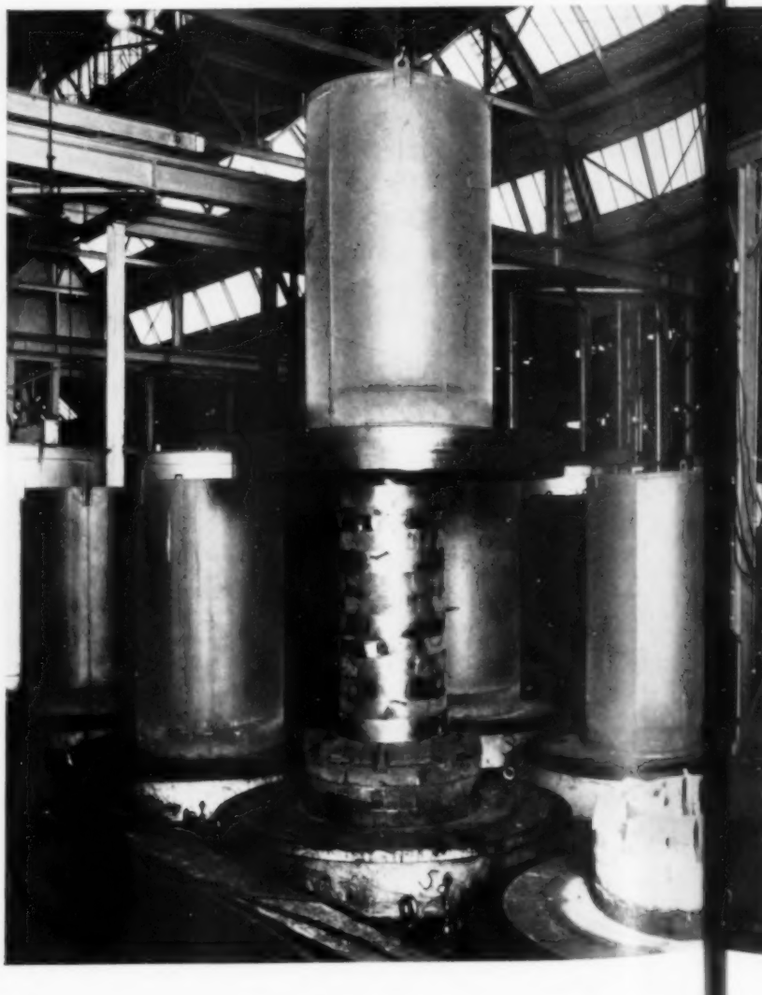
Coke-oven gas, generated in the company's ovens a mile away and piped to the furnaces, is passed through and around the coils inside the cover at a pressure of 1½ oz. Oxygen, moisture and sulphur are removed so that the gas when used contains approximately 60% hydrogen and is non-oxidizing. Two gas inlets and one outlet are built into each base.

Equilibrium between a carburizing and an oxidizing atmosphere, that is, a truly neutral atmosphere, is difficult to maintain, but whereas a slightly carburizing atmosphere surrounding steel at annealing temperature will produce only a thin deposit of soot on the outermost strand, steel in an oxidizing atmosphere at annealing temperature will form a hard scale difficult to remove and a source of trouble in later passes through the rolls. Since the coils come to the annealing furnaces with an adhering film of lubricant from the rolls, practice at the Cuyahoga plant is to allow the atmosphere to become slightly carburizing.

Strip Cooled in Reducing Gas

The gas outlet is open while the strip is under heat and the stream of escaping gas is burned outside the furnace. During the cooling cycle, the gas pressure is still on, but the outlet valve is closed so that pressure will be maintained in the cover to prevent air from getting to the charge. When the charge is cold, the empty cover is passed

Empty Base at Right Foreground; Loaded Base With Cover Suspended Overhead Next; Two Bases With Covers Lowered Next to Left. Top of furnace shells can be seen in the background



over a gas flame to burn the remaining gas without chance of explosion.

Mechanical handling equipment is provided everywhere possible. An overhead crane loads and unloads the coils by a magnet and also handles the cover. The row of loaded bases (one ready for annealing, one directly under the furnace, and the others in various stages of cooling) is moved forward by a cable hooked under the base of the last car and pulled by a motor at the other end of the pit.

The furnaces are handled by a gantry frame spanning the four tracks. Its posts carry side guides to align the furnace shell while it is raised and lowered.

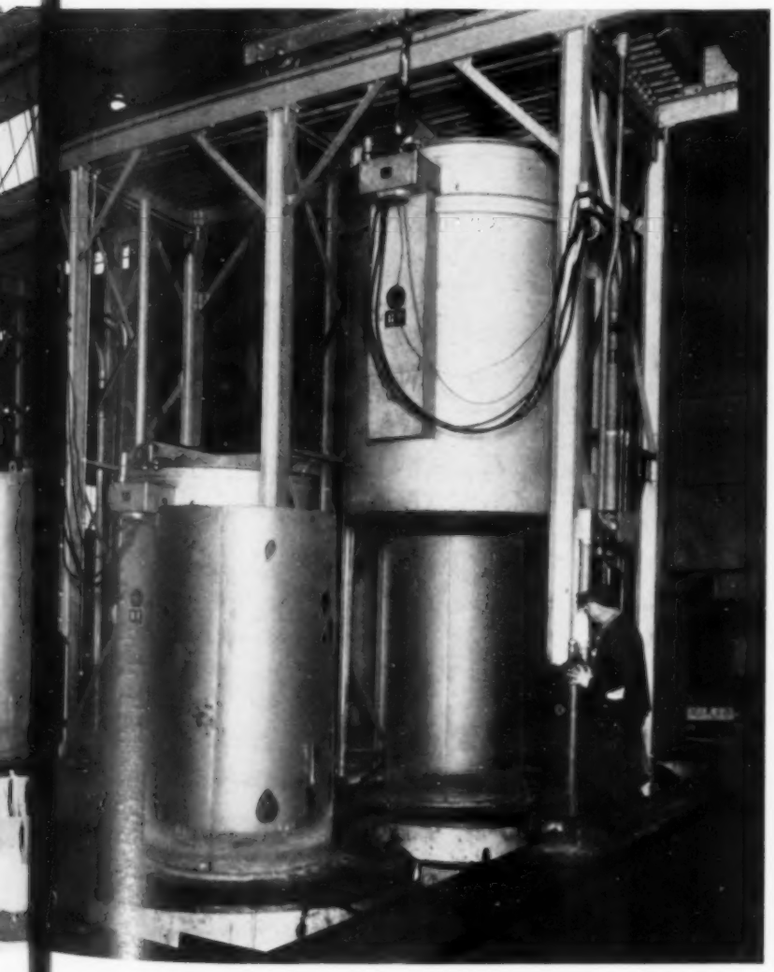
When a charge is completely cooled and unloaded, the base and its truck are returned by the crane to the charging end of the pit, ready for the next batch.

Each furnace has its own recording and controlling pyrometer which holds the temperature in the space between the furnace and the cover to a plus or minus range of 10° F. About 85% of the strip annealed in these furnaces is low carbon basic steel. Annealing temperatures are between 1250 and 1400° F., depending on the physical properties desired in the completed material. Six to ten hours are required for heating, depending upon the size of the charge. Cooling time is between 24 and 32 hr.

Decision to make the present installation of furnaces resulted from an intensive experimentation with a single furnace. The value of an electric furnace for bright annealing coiled strip had to be determined, as did such operating facts as heating and cooling cycles, costs of power and labor, and the adaptability for quantity production. These data were then compared to those previously obtained with existing furnaces.

Such a comparison showed that the electric annealing furnace produced a better quality of product at no higher cost. A unit of heat from electricity costs more than from gas, but this was more than overbalanced by the better insulation (made possible by the furnace design), by less time consumed in coming to heat and soaking, and by a smaller differential between the temperature of the source of heat and the charge.

Gantry for Handling Furnace Shells. While the shell is raised, the line of cars moves forward, bringing a cold load to the position just held by the hot one



Covers Absorb Little Heat

A second and most important factor in the greater efficiency of the new furnaces was that the weight of the strip being annealed constituted between 80 and 90% of the total weight of the material heated, as compared with 30 to 45% when heating covered charges in a gas-fired annealing furnace.

Since these furnaces commenced operations, more accurate heat control has meant more even annealing. Working conditions have also been much improved by the complete absence of smoke and fumes.

Requirements of Steel for Cold Heading

By H. W. GRAHAM
General Metallurgist
Jones & Laughlin Steel Corp.
Pittsburgh, Pa.

EVEN THOSE IN DAILY CONTACT WITH the wire industry are not apt to appreciate in how many varied applications steel wire is used. Among them are armored hose, fencing, screens, nails, bolts, screws, hoisting cable, chain, steel wool — a partial list to indicate the broad field that absorbs about one out of every twelve tons of steel made in the United States.

Wire for cold heading represents in tonnage and importance the largest single item. The present discussion will therefore confine itself to basic open-hearth steel for such purposes. It is usually "rimming steel," and requires an entirely different practice than, say, steel for rope wire.

Steel Making — As the carbon content is reduced in the basic open-hearth process, there is considerable evolution of gas, and when the bath becomes sufficiently pure much of this gas (largely carbon monoxide) is absorbed into the steel. Later this steel is poured into an ingot mold, and as the temperature drops the gas-dissolving power of the steel decreases, and the escaping gas produces an effervescent action, which causes the metal to solidify in successive rims about the top of the ingot. Steel of this type is ordinarily called "rimmed steel."

While the gas is escaping, the steel that freezes out of solution is relatively pure and clean, although likely to show blow-holes and gas bubbles. When the gas content has dropped to the amount corresponding to the solvent power of the steel at that temperature, effervescence ceases; and the remainder of the ingot solidifies quietly. This remainder in the center of the ingot is somewhat higher in carbon, phosphorus, and sulphur than the outside shell.

As is well known, there may be added to the melted steel combinations of aluminum, silicon, and other elements which either eliminate the excess gas or render it inactive. Steel so treated solidifies with little or no effervescence and is called in steel-works parlance "killed steel." Solidification proceeds somewhat more rapidly than in the case of rimmed steel, with lesser segregation of chemical elements.

Properly speaking, the terms rimmed steel and killed steel refer only to steel with less than 0.20% carbon. Steels with higher carbon content or with appreciable percentages of manganese, silicon, or sulphur, have less solvent power for gas and in them an effervescent action cannot ordinarily be produced. Such steels may be said to be self-killed.

General Effects of Analysis

Unfortunately, there is a tendency in some quarters to over-emphasize the importance of minor variations of analysis. In a given situation, for instance, a fabricator may change the acceptance limits from a conventional 0.30 to 0.60% manganese to a range of 0.50 to 0.60%, thinking that he has thereby cured all his troubles. Such moves, which unfortunately are not infrequent, can have little if any justification, and they place upon the steel maker a burden of cost which must ultimately be borne by the purchaser.

Carbon — The influences of carbon on properties and treatment are too well known to require discussion. Where *very* uniform physi-

cal properties of a steel product in its final form are desired, the result can hardly be obtained by merely restricting the carbon content to intolerably close limits, for they depend upon a number of other variables: *(a)* Variation in the rate of structural transformation from austenite to pearlite or other intermediate products, *(b)* variation in physical reaction to cold work, and conjointly *(c)* variation in age hardening. The degree of variability of these reactions depends upon the initial quality of the steel, but carbon content is only one factor in this initial quality. If a conventional and standard range of carbon content, say 0.30 to 0.40%, results in a product having too wide a variation in physical quality, the solution will seldom if ever rest in restricting it to some such impracticable limits as 0.32 to 0.34%.

Manganese also increases hardness and causes steel to show a more pronounced reaction to quenching and other heat treatments. As compared to carbon, it increases hardness and strength with less loss of ductility. It is therefore useful for requirements where great strength and high ductility are both indicated.

The relation of manganese to physical properties follows a long curve of gentle slope with no sudden changes below 3%. For this reason, there is little difference from any practical viewpoint between specifications for carbon steel containing say 0.30 to 0.60% manganese and 0.50 to 0.80%.

Phosphorus contributes to increased brittleness, and it has other influences not as yet well understood. After some years of research we are just beginning to achieve technical grasp of a situation which for 50 years has been made up largely of practical ignorance and technical mystery.

Sulphur — The much maligned element sulphur is really a modest and helpful servant to many users of steel. While it is troublesome in hot working, in the cold steel it helps machinability and has no clearly harmful effect. As one of the largest manufacturers of high sulphur steel in the world, the Jones & Laughlin organization has studied its effect for more than 20 years without being able to isolate any real harm to either the static or dynamic properties of steel. This may not agree with

John P. Mudd Photographs for the Midvale Co. Some of the Hot, Exhausting Work Necessary to Make Steel of Uniformly High Quality

general opinion on the subject, but these statements are made advisedly.

Silicon is a hardening element, without any pronounced detrimental effect upon ductility. It is commonly used with the intermediate or higher carbon grades with beneficial effect. In the lower carbon grades, it is markedly conducive of seaminess. If carbon content is 0.20% or under, silicon should not be specified as a constituent of basic steel. Silicon should be used as a deoxidizer of higher carbon heats and should not be used on lower carbons, while aluminum should not be used on higher carbons, but may frequently be used to advantage on the lower carbons.

Aluminum—Some think that the steel maker uses aluminum to doctor up a poor heat of steel. This is far from the truth. In the best practice it may be used to assist in removing the minute residual traces of iron oxide which remain after all that is possible has been accomplished with less concentrated deoxidizers.

A short time ago a manufacturer placed an order for cold punched nut steel and specified that it must not contain any trace of aluminum. He had been experiencing breakage in punching, and thought the steel was brittle because aluminum had been used in its manufacture; possibly he had gotten to this position after learning that aluminum is commonly used (at about 1.00%) in steel which, when nitrided, has the hardest case!

Aluminum does, however, have one byproduct which may be regarded with suspicion. When it performs its function as a deoxidizer, aluminum oxide is formed. Under favorable conditions most of this byproduct can be eliminated, but in any event some traces of it will remain and may therefore be considered as an abrasive which reduces tool-life in machining. This effect is not of great importance but it is a factor worthy of some attention.

Aluminum has a further influence unfavorable to machinability in that it tends to preserve toughness during cold working operations. Since machining is distinctly a cold working operation, aluminum is unfavorable to that condition of brittleness which is associated with best machinability.

Aside from the single field of machinability, however, it is difficult to be convinced of any harmful effect of aluminum. There are those who will say that alumina inclusions contribute to fatigue failures, but thoroughly conclusive evidence on this score is lacking. In general we are distinctly of the opinion that the importance of "dirty steel" has been greatly overemphasized. Much evidence suggests that visible inclusions have very little direct influence upon the physical properties of steel.

Wire for Cold Heading

A few years ago all wire for cold heading was of a grade approximately 0.06% to 0.12% carbon. The quality even in this soft steel did not always lend itself with complete satisfaction to the cold upsetting of bolts and other products but steady improvement was being made. Then came the movement toward greater strength by the use of higher carbon steel with a consequent increase in hardness. This development was inevitably accompanied by an accentuation of the problems of rupture, embrittlement, and die wear.

In the last five years there has been an increased interest in the subject of plastic flow and considerable progress has been made toward an understanding of the underlying laws. This has begun to influence the manufacture of the wire, but much further information must be available before the matter is completely under control.

We do know now that cold heading quality is not directly proportional to the carbon content. This is another way of saying that Brinell or Rockwell hardness is not strictly a function of carbon content. But further it is known that Brinell or Rockwell numbers constitute an inadequate gage of cold heading quality.

In any cold working operation steel becomes harder and more brittle. This is widely known, but it is not generally understood that these effects vary somewhat even when any given content of carbon or other commonly analyzed element is held to closest limits. This statement, we may say, has been proven beyond contradiction, and it carries with it an almost immediate conclusion: There must be another agent or group of agents responsible for the varying susceptibility of steel to hardening by cold work. The problem is therefore the iso-

In This and the View on Page 26 Margaret Bourke-White Photographs the Product of Russell, Burdsall & Ward Bolt & Nut Co.

lation of these other agents and their control.

The hardening and embrittlement that occurs under plastic flow in cold working is related to the phenomena of aging and precipitation hardening and may therefore be supposed to result from the same causes. These causes are postulated to be (aside from carbon) such elements and compounds as iron oxide, nitrogen or oxygen.

To restate it in more specific language, steel has a certain impact strength and a certain hardness in its initial condition. With as little cold work as 1% deformation, there is an appreciable drop in impact strength and an increase in hardness. These effects become increasingly greater as the cold drawing or cold heading operation is carried on to higher percentages of deformation. Some measure of control can now be exercised over the embrittlement, but there is as yet little control of the hardening which is associated with cold work.

In certain applications it would be desirable to have a steel that would be substantially unvarying under the influence of cold work. This condition would avoid brittleness in cold headed products and would avoid undue hardening, but in some cases brittleness and hardness are desirable properties. The ideal condition would be found in a situation where the impact strength and hardness resulting after a cold working operation could be predictably controlled within certain desired limits.

These considerations have been presented at some length, because of their importance in connection with cold heading, but they apply with equal force to any cold working operation.

"Normalized" Wire

Manufacturers place considerable stress on die wear. Unfortunately, the metallurgist has little to offer in this connection. The principles involved in abrasive wear are probably less well understood than in any other major industrial operation. Therefore for the present, improvements in any specific case must come from the cooperative efforts of the mechanical engineer and the metallurgist, and must be based upon practical measures rather than upon fundamental concepts.

Use of higher carbon steel of greater strength and hardness has accentuated not only the wear of dies, but all other manufacturing problems. The most helpful measure which has been introduced is a normalizing treatment. It produces a more workable wire and achieves a generally improved level of physical properties. As now commercially practiced, it is not "normalizing" in the accurate sense of the word,

but is in reality heating for a fairly prolonged interval at a temperature well over the critical with properly controlled cooling so as to induce grain growth rather than grain refinement.

Proper regulation of the time and temperature conditions gives some degree of control over the physical properties, as well as grain size and metallographic structure. This operation will find wider use and more elaborate development as time proceeds.

Rolling vs. Cutting of Threads

A considerable proportion of cold headed bolts are threaded by cold rolling in both the higher and lower carbon grades. This constitutes a drastic operation which is very apt to cause failure by rupture. The manufacturer must take many precautions in making such steel and the purchaser should always inform the supplier that a given lot of wire is to be so handled.

Where threads are cut by machine an entirely new field of metallurgical conditions is opened. Bolt manufacturers quite naturally seek to raise to the ultimate the number of threads cut per die. If the machining quality of the steel were the only consideration, the metallurgist and the steel maker could provide a metal of excellent machining quality. Unfortunately a thread cutting operation on a cold headed bolt presents the opposing requirements that exist in so many fabricating processes.

For best cold heading, steel must be soft and plastic; for best machining, soft and brittle. For heading quality, rimmed effervescing steel made by the open-hearth process is ordinarily used, but the purer, softer surface on these rods is sometimes poorer in machining quality. In this situation, the metallurgist is always striving to obtain the ultimate in both of the two opposite directions by working in a middle ground which is actually non-existent.

Wire for Cold Rolling — In some plants round wire of fair diameter is cold rolled into flat sections which are sheared into nut blanks, punched and tapped. This procedure involves a drastic cold rolling operation which tends to harden the steel greatly and this makes it difficult to provide a really free cutting steel for the subsequent threading operation.

The production of armored wire, flexible conduit, or armored tubing such as gasoline hose, has somewhat similar requirements to cold rolled nut steel, but the rolling is down to smaller thicknesses and machining is not involved. In this application killed steel of maximum softness is ordinarily used instead of the softer but less homogeneous rimmed steel, since the latter has a tendency when rolled into thin ribbons to spread a variable amount.

Rolling Stainless Steel Plate

By L. M. CURTISS
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THE TERM "STAINLESS PLATE" COVERS a wide range, both in the metallurgy of its ingredients and in its size. "Stainless" in this article is restricted to the metals with which we at Lukens Steel Co. are familiar, (*a*) the chromium ferrites with 15 to 18% chromium, and (*b*) the austenitic steel with 18% chromium and 8% nickel. Both (*a*) and (*b*) have low carbon content.

As to size, it begins at $\frac{3}{16}$-in. gage with a possible spread of 200 in. long and 90 in. wide, and the current demand takes it up to $\frac{5}{8}$-in. gage, 300 in. long and 160 in. wide. It can thus be seen that the following discussion is limited to the production of very large plates necessary for the fabrication of plant equipment (in which the American industry unquestionably leads the world). Really there is no reason why it is necessary to restrict the dimensions in heavier gages over $\frac{5}{8}$ in. to those just mentioned, because the only limiting factor is the size of the rolling mill and the ability of the steel maker to furnish sufficient sound metal in one ingot.

Rolling of large plate is quite different from the making of other stainless products in that the plate must generally be finished in one operation. Occasionally it is necessary to make one reheat, but, due to the expense of handling, anything but a single conversion from slab to plate is not considered commercial. Smaller products may be and are reheated between operations because of the ease and speed with which they can be handled. Since this necessity for a single operation exists on heavy plate, care and attention to operating details are of utmost importance.

The outstanding feature which must be considered is the fact that the manufacture of a product large in size requires a large mass of costly metal, and uses a large and expensive rolling mill. Any carelessness or miscalculation may result not only in the loss of the rolled metal, but also in the breaking of a roll or some other part of the machinery. Such a mishap would be costly, especially when compared with machines and products of smaller sizes.

Proper Slab or Ingot

The slab or ingot from which the plate is to be made should be given most careful attention. Consideration, of course, should be given to its cleanliness and freedom from slivers and cracks, since it is obvious that a satisfactory product cannot be made from material which is metallurgically questionable. Mechanical deformities cannot be overlooked, since any irregularity in the slab will be exaggerated many times after it has been stretched out into a plate, which might be as much as 300 in. long and 160 in. wide.

There are four conditions which should be avoided in preparing metal for large plates:

1. The direct rolling of ingot to plate should always be avoided because of the coarse crystalline structure as cast. As shown in some detail by Messrs. Johnson and Sergeson in METAL PROGRESS last October, the large crystals form a weak body which will tear readily under

the stress of rolling, and thereby produce a defective plate. An ingot broken down to half its original thickness will generally develop all of its surface defects, which can then be removed by chipping.

2. A slab which is extremely long and severely tapered will naturally roll into a plate, *A*, much wider at one end than at the other. Usually a rectangular sheared plate is required by the purchaser, and consequently it is most important to have sufficient width in the narrow end of the plate as rolled in order to cut the pattern. If the ingot has too much taper, the wide end of the plate will have altogether too much scrap on the sides, and unless this waste is taken into consideration in the beginning, the plate may be too short to cut the pattern *B*.

3. Deep chipping or grinding on the longitudinal slab edges should be avoided, if possible, as the effect is exactly the same as that just mentioned, except that the narrow point may come in the middle of the plate *C* as rolled, rather than at the end. Due to overroll — a condition described in detail in a later paragraph — there is also the danger of the sheared plate *D* being laminated when there is insufficient side scrap at any point.

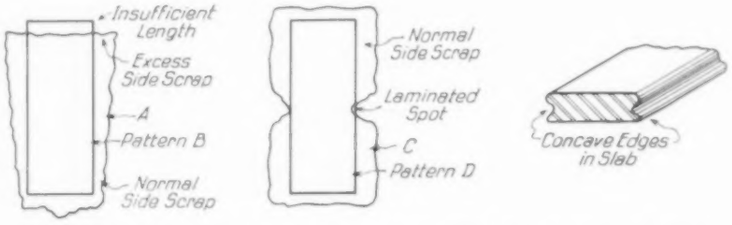
4. The most dangerous condition is to have concave edges running longitudinally with the sides of the slab. This condition causes an overroll in the sides of the plate as rolled, the depth of which is quite astonishing. Even with a liberal side allowance for scrap, the sheared plate may then be laminated.

An ideal slab is one in which the length is 1.5 to 2 times its width. The ratio of its thickness to the gage of the finished plate should be between 15:1 and 20:1. The sides should be square or slightly convex.

Before charging cold alloy steel slabs, the heating furnace should be cooled down to about 1600° F. After charging, the metal should be allowed to absorb the furnace heat for a time before the temperature is increased by firing. This precaution is necessary because sudden and uneven expansion of the metal is apt to cause internal cracks, or checks in the surface of the slab.

The metal is generally heated slowly with gas or oil to about 2000° F. At this point it is allowed to soak thoroughly, until the interior of the slab is heated, and then the temperature is increased quickly to 2250° F., when it may be drawn for rolling.

The responsibility for this heating operation should not be left to the heater alone, but also by some member of the metallurgical department, whose duty it is not only to check the temperature but also to make a record of the heating procedure. A rule of thumb method which has been used successfully for the rate of heating is: One hour for each inch of slab or ingot thickness.



Conditions to Be Avoided When Rolling Large Plates: Left: Ingot with too much taper; Center: Deep chipping on edges of slab; Right: Concave edges causing overroll

Rolling Without Cooling Water

Probably the greatest source of trouble in rolling high alloy plate, and one which may involve severe financial losses, is breakage of the rolls themselves due to expansion. The reason for such accidents is as follows: Each plate must be rolled for a short time on a dry roll, or at least on one which is not drenched with cooling water. It is quite necessary to adopt this procedure because stainless irons and steels are much harder and tougher than ordinary carbon steels and consequently they give greater resistance to the rolling action. Reductions in each pass must necessarily be smaller, more passes are required, and yet all the work must be done on a single heat. This loss in time is compensated for by conserving the heat in the ingot or slab.

Of course roll water not only cools the rolls, but the red hot piece passing between them (which with stainless iron or steel is most objectionable). The question as to how long this

water should be turned off is dependent entirely upon how difficult the plate is to make. A plate of light gage and large area requires more dry rolling than one of heavier gage and smaller area. It is quite advisable to alternate the alloy rolling with an ingot or slab of carbon steel; with the latter the rolls are drenched with a full flow of water, and consequently their temperature is kept down. The rolling of one alloy ingot after another would dangerously overheat the rolls.

The first step in the rolling is to remove any oxide formed in the heating furnace. This is small in amount on steels so high in chromium, and can easily be blown off by applying salt or water-soaked bags on the first few passes in the mill.

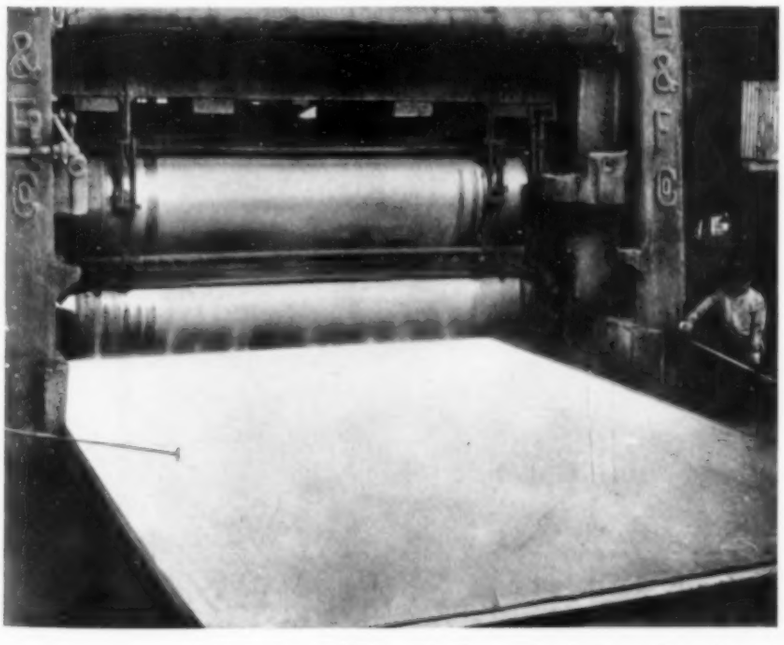
Rolling for width is undoubtedly the step which should be watched with extreme care, because all stainless irons and steels have a tendency to overroll more than ordinary steels. This overroll is simply a laminated condition which forms on the sides of the slab, because whatever work is done by the rolls does not penetrate readily into the slab's interior but is confined to a great extent to the two rolled surfaces. Since stainless resists the rolling action more than carbon steel, the tendency to overroll is more pronounced and consequently a larger allowance for side scrap must be given. This is particularly true in rolling plates of extreme widths. It is perfectly possible to have an overroll lamination of 5 in. on each side of a plate 130 in. wide, especially if the original slab had concave edges before rolling.

After the width is obtained by cross rolling, the procedure is only one of reducing the metal to the proper gage in the least possible time. This sounds quite simple, but extreme care must be exercised in drafting, as the metal cools quickly and is consequently much harder than carbon steels. The drafts taken during this reduction should be approximately 60% of those required in rolling ordinary carbon steels.

The 15 to 18% chromium iron hardens quickly as it cools; below a certain temperature an added hardening effect comes from any cold work which may be done. 18-8 does not air harden, but acquires hardness from cold working, which is hastened because of its rapid loss of heat. The term "cold working" in the above sense means any work done below 1700° F.

The type of mill has a decided bearing on the ease with which the rolling is accomplished. Two-high or four-high reversing mills are ideal because the working rolls must be turned to the same diameter and their surface speed is equal. Consequently, there is no tendency to curl the slab. A three-high mill is apt to cause more curling because the piece must pass between two rolls of different diameters and different surface speeds.

Speed and the absence of interruptions are the most important features in the rolling of stainless plate. This is particularly true in the making of wide material of light gage. Plates of $\frac{3}{16}$ or $\frac{1}{4}$-in. gage usually require double or even triple heating, intermittently with the rolling, because a point is reached where the steel becomes so cold and hard that further reductions in rolling cannot be safely made.



Mill at Lukens Steel Co. Capable of Rolling Plates Up to 206 In. Wide

Cold rolling has an added disadvantage for it creates buckles in the finished plate, and also a heavy center gage. These conditions come, of course, from the spring in the rolls, and if excessive, may result in a broken roll.

Finishing Operations

After rolling is completed, the plate is usually too cold and hard to flatten in the straightening rolls, so this operation is deferred until after annealing. Shearing of the patterns is also postponed for the same reason. If the plates are sheared as they come directly from the rolls, there is always the danger of ruining one of them by cracking it. Chipping the shear knives occurs if the metal is exceptionally hard.

A comparison of Brinell hardness of ½-in. plate is very interesting:

	½-In. Plate	
	As Rolled	Annealed
15 to 18% chromium	173	149
18-8	207	143
Soft carbon steel	126	103

After the rolling operation is completed the usual process is as follows:

1. Anneal to remove rolling strains and to soften the metal. (*a*) 15 to 18% chromium requires a thorough equalizing temperature from 1400 to 1450° F. and a furnace cool. (*b*) 18% chromium, 8% nickel requires a thorough equalizing temperature at 1900° to 2150° F. and a water quench (air cooling may be used on thin material).

2. Sandblast to remove the hard, closely adhering scale.

3. Pickle to remove any embedded scale and to give the characteristic silver-gray appearance and also the luster which is demanded by the trade. This obviously requires very large tanks, as compared to those suitable for sheet or strip.

4. Cold flatten in straightening rolls.

Common carbon steel plate of uniform excellence can be produced by good general practice, plus careful mill routine. This, however, is not true of stainless plate. No general procedure can be laid down for the production of this material; too many variables enter into its making, variables which cannot be anticipated or provided for in a general practice. Only an organization skilled in the handling of high alloys, equipped with the required metallurgical personnel, and trained to take infinite pains can produce stainless plate successfully — and economically. The latter is a most important consideration, because a failure anywhere along the line ruins costly metal.

Acid & Wash Tanks to Clean Scale From Stainless Plate & Dished Heads

Heat Treatment of Cast Iron

By H. BORNSTEIN
Deere & Co.
Moline, Ill.

GRAY CAST IRON IS DIRECTLY comparable to steel in its reactions to heat treatment, since the only fundamental difference in the composition of the two materials is the presence of free graphite particles in the cast iron. Its heat treatment may therefore be broadly divided into three classifications, namely, (1) annealing, (2) quenching and drawing, and (3) special heat treatment.

Annealing may be done for three reasons, either to relieve internal stresses, to soften before machining, or to convert a white or mottled iron into a stronger gray iron. The well known annealing of white iron into malleable iron, so called, will not be discussed in this article.

Annealing to Relieve Internal Stresses — Heat treatment for the relief of internal stresses is variously called aging, normalizing, or mild annealing. This can be accomplished by heating at 800 to 950° F., holding at temperature for 30 min. to 5 hr. depending upon section, and slowly cooling in the furnace. This treatment will slightly decrease the hardness of the metal, decompose a little cementite, and will affect the strength only slightly.

Softening for Machinability — Sometimes the desire is to soften the casting in order to facilitate machining, and a good proportion of the heat treatment done on cast iron in production is of this class. The temperature range most commonly used is 1400 to 1500° F., although temperatures as low as 1200 or 1250° F. have been used satisfactorily. (Highly alloyed irons are sometimes annealed at temperatures up to 1800° F.) In all annealing, care should be taken to prevent oxidation of the surface.

In general, softening for machinability is attended with a decrease in the strength and in the amount of combined carbon and a corresponding increase in the graphite content. Irons containing carbide-forming alloys (elements such as chromium) are more resistant to annealing than the common gray iron, and the temperatures used for annealing are considerably higher.

Completely annealed non-alloy cast irons may have Brinell hardness values of from 120 to 130, whereas completely annealed alloy irons

may have Brinell hardness values of 130 to 180 depending upon the composition.

Annealing White or Mottled Irons — In order to obtain commercially machinable irons of extremely high strength (from 60,000 to 90,000 lb. per sq.in. in tension) irons white or mottled as cast are annealed to decompose the carbide into ferrite and graphite. Such irons are commercially called "semi-malleable" or "short annealed malleable," and should not be confused with true malleable iron (which, as is well known, is composed of ferrite and rounded graphite particles called temper carbon).

Total carbon in these special irons is usually held in the range 2.0 to 2.8%. Silicon content depends upon section and does not exceed 1.80%. A typical annealing cycle for this material is as follows: Heat to 1700 to 1750° F. and hold for 1½ to 3 hr. Cool to 1375° F. for 3 hr., then subject to one of the following: (*a*) Oil quench and draw, (*b*) air cool, or (*c*) cool slowly in furnace.

Resulting Brinell hardness will vary according to composition from 150 to 400. Alloying elements such as nickel, chromium, or molybdenum may be used. The resulting product has high strength with measurable ductility and good impact resistance.

In order to increase wear and abrasion resistance of cast iron, it may be quenched from above the critical temperature. Heat treatments similar to steel heat treating practice should be employed to make good cast iron better and not to attempt to make poor cast iron a fair product. For obvious reasons, common soft gray irons that have a coarse interlocking structure and a ferrite matrix are not materially improved by heat treatment. They do not harden satisfactorily, while subsequent drawing may or may not measurably improve the strength.

Cast iron, to be heat treated satisfactorily, should have a microstructure in which the graphites flakes are small, well distributed, not interlocked; the matrix should preferably be pearlitic in character. Graphitic carbon should approximate from 2.0 to 2.5% in such a cast iron, suitable for heat treating, and the combined carbon should range from 0.50 to 0.80%. Given these conditions, gray iron castings respond to quenching and tempering much in the same way as carbon tool steel. The hardness increases in direct relation to the rapidity of cooling through the critical range. Brinell hardness values up to 600 may be obtained by hardening, depending upon the composition of the metal employed and the quenching medium. Extremely high hardness values are obtained after heat treating irons not classed as machinable in the as-cast condition.

Softening after hardening proceeds uniformly as the drawing temperature rises above 350° F. (Drawing below 350° F. has little effect on hardness or structure.) The strength and impact are definitely improved by drawing.

Quenching and drawing of cast iron should therefore prove of considerable value to industry. As experience in the properties of heat treated cast iron is continued and the possibilities of such hardened iron become more widely known, it will go far in extending the use of cast iron as an engineering material.

The hardening effect brought about by rapid cooling from temperatures above the critical point is usually accompanied by a deterioration of the strength properties, but the latter are immediately restored by tempering. Thus, by suitable hardening and tempering a definite improvement in the strength properties can be obtained. Where strength properties and shock resistance are not of particular importance, the draw may be omitted. The diagram on page 34 shows the effect of quenching and drawing on the ultimate strength and Brinell hardness of cast iron. This illustration was taken from a recent paper by J. E. Hurst published in *Foundry Trade Journal*.

In 1922 Harper and MacPherran presented a paper on "The Heat Treatment of Cast Iron" before the American Foundrymen's Association. The second drawing is taken from that paper and shows the effect of various quenching temperatures on the physical properties of cast iron. Attention is invited to the sharp rise in the hardness as the quenching temperature is increased above 1350° F. Below this temperature, quenching has the same effect as slow cooling or annealing.

Heating for hardening should be carefully done — the casting should be heated slowly and uniformly, and held for a sufficient time to insure that all parts have received the max-

room or quenching temperature. A safe minimum is 30 min. for comparatively small castings. If the castings are small and of symmetrical design, they may be preheated to 300 to 500° F. in one furnace and then transferred to another furnace which is held at the quenching temperature. This promotes economy of operation, with little danger of cracking.

Quenching temperatures now used on most irons in production are from 1450 to 1550° F. The quenching medium most commonly used is oil, although water and air are also used.

The quenching medium used is dependent on the composition of the metal. With some compositions the castings may be quenched in an air blast or still air and desirable hardness secured. In the French Exchange Paper to the American Foundrymen's Association (presented at the Annual Meeting in Chicago last month) Delbart shows the advantages obtained in the quenching of low carbon irons with high manganese content.

Manganese lowers the transformation point during the heating period, particularly when the manganese content reaches 2%. The lowering of the critical range during the cooling period is still more marked when the manganese reaches 2%, at which point the castings are susceptible to hardening by cooling in still air. M. Delbart obtained excellent results with irons having 2.5 to 2.8% total carbon and 2% manganese. Hurst (*Foundry Trade Journal*, 1931) has also called attention to the value of the higher manganese in the heat treatment of cast iron.

Other investigators have shown that with a manganese content of 1% and 1 to 2% nickel a marked effect on quenching is noticeable. That is because the influence of manganese and that of nickel are in the same direction and their respective influences for good are added to each other.

Composition of the metal is largely governed by the machinability requirements in the as-cast condition, for the castings are usually rough-machined before hardening and drawing. Finishing is by grinding. The parts grow a small amount during heat treatment, and allow-

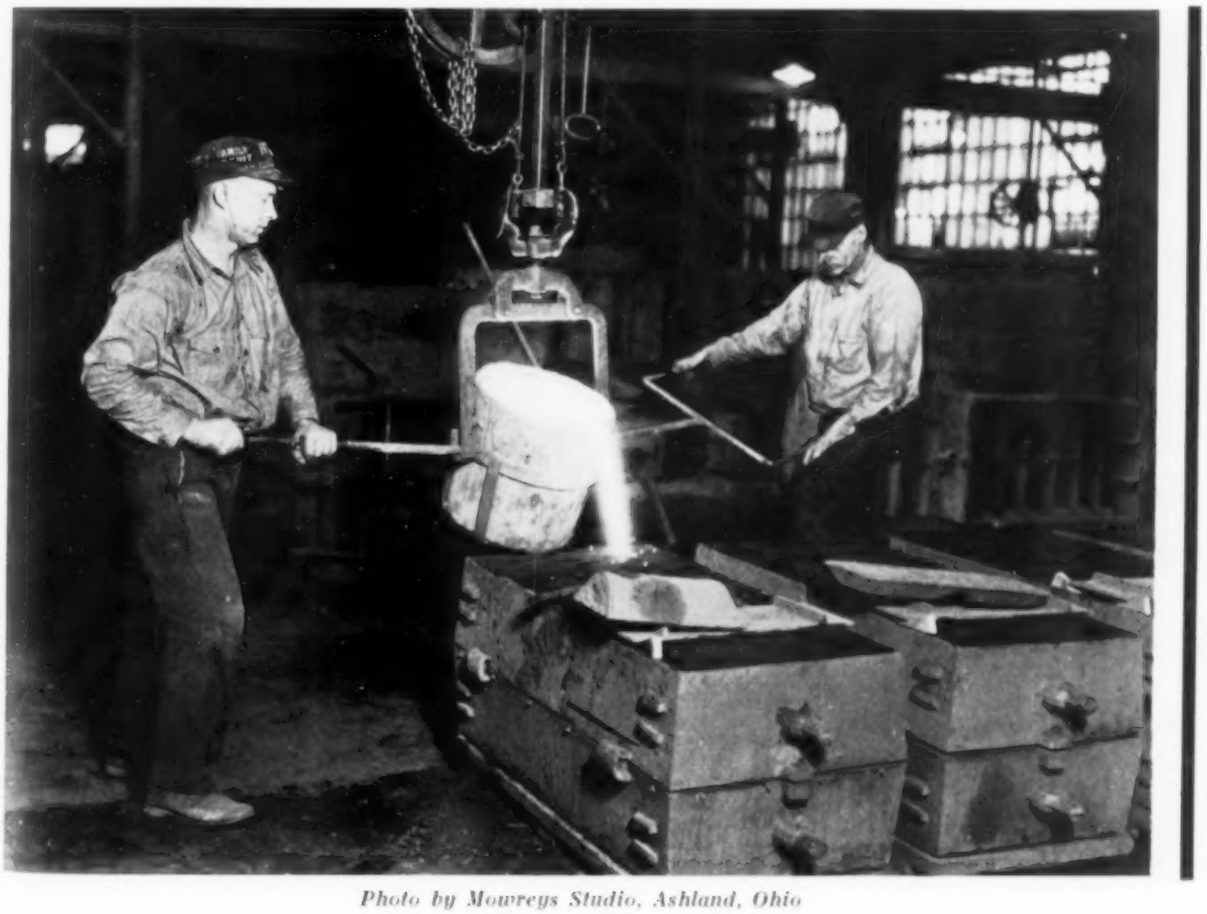
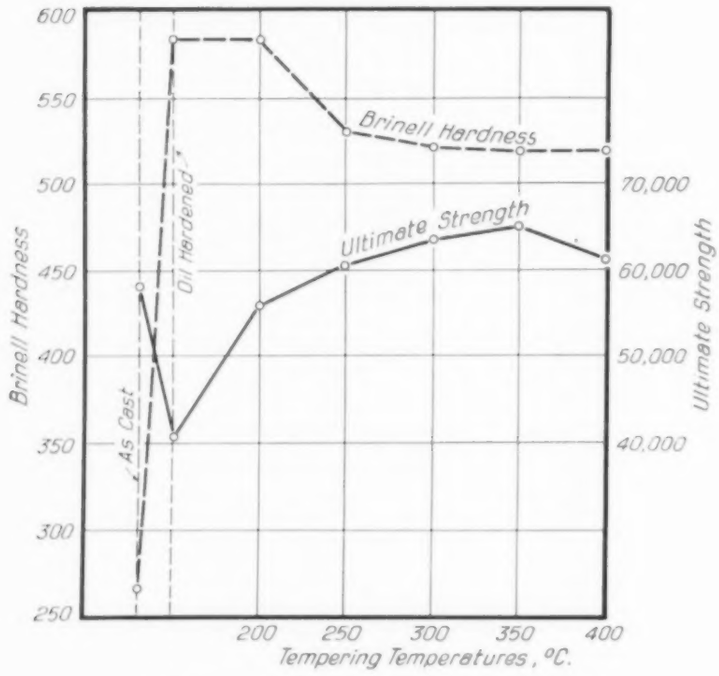


Photo by Mowreys Studio, Ashland, Ohio

ance must be made for this in leaving stock for finish grinding.

Iron castings which are heat treated in production include cylinder liners, forming and forging dies, wearing plates and gears.

Some data on the wear resistance of hard-



A Pearlitic Cast Iron Hardens After Quenching and the Changes in Strength and Hardness by Subsequent Tempering Are in a Manner Analogous to Steel. (J. E. Hurst)

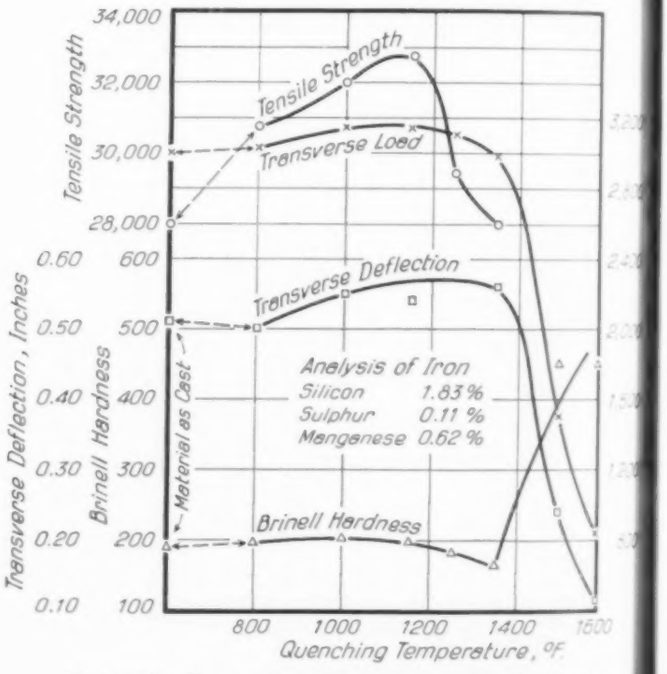
ened cylinder liners in heavy-duty internal combustion engines are available, which indicate that hardening increases wear resistance in the as-cast condition. Cylinder liners of this type have been in use both in the United States and England for two or three years only, so that final performance data are not available.

The first micro shows the structure of a cylinder liner as cast. It had a Brinell hardness of 207. After oil quenching from 1500° F. (held 25 min. at temperature) and drawing at 300° F. for 1 hr., the liner had Brinell hardness of 480, and structure as shown in the second micro.

Another cylinder sleeve of the same composition was quenched in the same way and then drawn for 30 min. at a temperature of 600° F. The Brinell hardness after this higher draw ranged from 438 to 453. (The composition of the metal used in these cylinder sleeves was silicon 2.00%, total carbon 3.29, sulphur 0.050, phosphorus 0.175, manganese 0.65, nickel 1.50, and chromium 0.21%.)

In suitable thin sections, plain unalloyed cast iron is capable of being hardened in oil if quenched from the correct temperature. In thicker sections it has been shown that an ordinary cast iron does not harden usefully after quenching in oil, but the presence of alloy constituents such as nickel and chromium or molybdenum increases the hardenability. Proper alloying elements in cast iron, just as in steel, have the effect of increasing penetration and also the degree of surface hardness obtainable. A higher hardening temperature is accompanied by definitely inferior results both as to hardness and as to strength values.

The metal may be completely or partially



Quenching From a Low Temperature Has the Same Effect as Annealing, But Quenching From Above 1350° F. Greatly Hardens Cast Iron. Transverse bars were 1x2 in. on 24 in. centers, heated 60 min. before quenching in water. (J. F. Harper)

annealed before hardening without appreciably affecting the response to quenching or hardening properties, provided coarse interlocking graphite is not present in the structure. Care should be exercised in respect to sudden changes in temperature both in heating and quenching, particularly where castings are irregular in section and where size is large.

Special Heat Treatments

Nitriding — Following considerable experimental work on the nitriding of cast iron, the process has been in use for the past year or two. Parts requiring extremely high wear resisting properties may doubtless be economically nitrided. Nitriding consists of heating the castings to 950 to 1000° F. in contact with anhydrous ammonia gas for 60 to 90 hr. Special cast irons were originally developed for nitriding purposes, low in total carbon and having chromium and aluminum for alloying elements — somewhat similar to steels adaptable for nitriding. It is claimed that chromium-vanadium irons also nitride satisfactorily.

A typical cast iron suitable for nitriding has the following composition: Total carbon 2.61%, silicon 2.58, manganese 0.61, sulphur 0.07, phosphorus 0.096, chromium 1.69, aluminum 1.43, and vanadium trace.

Nitrogen hardened cast irons for cylinder liners for various types of engines, compressors, and pumps are of particular interest. A considerable number of them have been manufactured and fitted to various types of engines, including gasoline engines for heavy vehicles and pleasure cars and high speed diesel engines. It is claimed that in all cases excellent results have been obtained.

In most cases the heat treatment of castings is carried on in the plant of the purchaser of the castings and not in the foundry. (Of course in many cases the manufacturer operates his own foundry and consequently does the heat treating also.) But foundries are beginning to put in heat treating equipment, recognizing the growth of this branch of the industry.

Considerable care is necessary in the heat treatment of cast iron. Just as in the heat treatment of steel, crude practices will mean crude results. Good furnace equipment and accurate temperature control are desirable and necessary. Metallurgical supervision is essential to uniform results. The thoroughfare type of furnace is popular and gives a good anneal. In the heating of cast iron, the heating should be done slowly and the flame should not be in contact with the work. Cast iron is more susceptible to temperature changes than steel, because cast iron is a more brittle material, and therefore proper care should be exercised.

In the hardening of cast iron, thought must be given to the quenching operation. In castings of complex design, this is especially true. It may be necessary to modify the composition so as to secure the desired hardness by an air quench instead of subjecting the casting to a more drastic oil or water quench.

The heat treatment of gray iron castings is in its infancy and we may expect considerable development in the next few years.

Nickel-Chromium Cast Iron Cylinder Liner As Cast and As Quenched and Drawn. Etched and magnified 250 diameters

Kaufmann-Fabri

Architecture, After a Century of Progress

Editorial

Exposition Promotes New Uses for Metal

CHICAGO'S Century of Progress Exposition affords an interesting comparison between direct advertising for over-the-counter sales and indirect publicity which may be converted into sales at some later time.

As an advertising medium the Exposition is attractive primarily to organizations selling direct to the public (and with only a few exceptions the exhibitors are of this class). Metal making companies are consequently represented to only a limited extent by commercial exhibits, yet they will benefit greatly by the indirect publicity metal is getting.

The Exposition, on the whole, is a triumph for the illuminating engineer. His ability to light adequately both the interior and exterior of the buildings (plus the ability of other engineers to ventilate window-less buildings properly) has been the ruling consideration in the architectural design and will undoubtedly be reflected in new structures for many years. Of course, all this means copper, iron and decorative alloys where metal was not used.

But there will be another influence exerted on the common citizen by displays of fabricated metal. If half as many people attend the Fair as the management hopes, about one out of every five in the United States is going to be exposed to a view of metals in unimagined applications to his daily life.

For instance, the most comfortable chairs in the many and very welcome lounges are certainly those made from steel tubing which look like a pair of inverted question marks standing side by side. Some of these have "cushions" of unbelievably yielding spring steel.

Then too there are small houses in which metals are used not only for frame and sheathing, but also in many new ways for furniture and fittings. The public may have looked at these in the movies, but at the Fair they can see, touch, and actually use them. Consciously or not they are going to visualize them in their own homes.

These new uses for metal, seemingly earmarked for popularity, will constitute a welcome outlet for metals, especially since it is probable that many established metal users operate in markets nearly saturated—at least for the time being. Manufacturing and selling organizations that are flexible enough to change from a line of dwindling importance to one which will catch the new demand are the ones that will profit.

Creep Strength Versus Creep Limit

STANDARDIZATION has many commercial advantages — yet now and then a mild protest is raised, lest excessive standardization stifle original work and hamper progress. That such a thing may come to pass was proven at a recent meeting of the American Society for Testing Materials.

Under discussion was a proposed method for investigating the relative stability of metals under load at high temperature. Criticism was not voiced on account of the experimental difficulties involved, the reproducibility of the results, or the fundamental meaning of the derived data, but centered about the idea that the proposal did not conform to more conventional methods of determining "creep," as outlined in a tentative standard adopted for conducting long-time high temperature tension tests.

In other words the new method of testing was not so good because it did not conform to standard — surely an indefensible position! The conventional method of determining creep strength is, briefly, to heat the specimen to a certain temperature and hold this constant, then load it and observe at intervals the change in

dimensions in the test piece. If temperature and load are properly adjusted, the initial plastic flow gradually decreases to a constant small rate. Several such high grade experiments at a given temperature will fix the approximate stress that will cause a certain metal to stretch at the constant rate of 0.01% in 1000 hr., and this is commonly assumed to be equivalent to 0.1% in 10,000 hr. or 1% in 100,000 hr. — a figure recommended for design purposes at the given temperature.

Under discussion was a new apparatus modified from one suggested by Rohn. It uses a long tube furnace through which a loaded wire is hung. At the lower end is attached an electric contact, acting through a controller so that a tiny stretch in the wire reduces the heating current slightly. In other words, the loaded wire is first heated a little above the plastic range, and as plastic extension starts, the temperature is automatically and gradually lowered until stretching stops. In this way a stable relationship between temperature, volume, and stress is gradually approached.

In appraising the relative merits of the two methods it must be remembered that the more conventional method of determining creep strength is expensive in time and equipment and at the end an arbitrary relationship (0.1% creep in 10,000 hr.) based on the sensitivity of the elongation measurement is derived for a metal which is different structurally from what it was when the test started. It is believed, however, that the test, when well done, will appraise the relative suitability of metals for high temperature service. Despite the fact that such a test procedure has been tentatively standardized, it would appear that it must be defended by its supporters as an accurate method of fixing relationships, rather than upheld as an ideal device for studying the fundamentals of plastic flow in metal.

Under these circumstances, any testing engineer is to be congratulated, rather than criticized, for bringing forth a test which he believes will rapidly and automatically determine the relationships between temperature and stress wherein a given metal does not change in volume. No one claims that this Rohn test, so called, will give the creep strength, so called, of the metal. All that it can do is to arrange a series of metallic alloys as to their relative creep limit. These relationships must then be interpreted in the light of prior service experience with similar materials.

Either test, it would appear, gives data which must be interpreted with the utmost skill. Consequently the test which presents accurate data with the least expenditure of time and energy is the one which will survive.

Research — Your Own or Your Customer's

Dr. Karl T. Compton, president of Massachusetts Institute of Technology, recently cited the American railroad situation as an illustration of the plight of an industry that neglects research. Then up rises Dean Young of Purdue University and says that the money expenditure in the railway researches in 40 years in his institution amounts to approximately 4¼ million dollars. Purdue deserves congratulation for a unique record of cooperation between a university and an industry, but the railroads can take little credit — several manufacturing corporations have expended that much individually in a single year.

Recent history makes it quite clear that if an essential industry will not study its own product and services with the view of improvement and diversification, its energetic customers will do it themselves, and in so doing will probably uncover and adopt interesting substitutes. That's what the railroads' customers have done — discovered a handier, more flexible method of transportation. Undoubtedly a far-seeing management would have done what the executives in another monopoly, the telephone system, have done — by continued research and improvement been able to anticipate developments and conform their operations to changing demand.

Producers of steel, copper, and the other metals might also ponder the desirability of emulating the more vigorous development and promotional work being done by the aluminum and nickel companies, since they undoubtedly wish to retain their present markets against inroads from competing materials, even if they fear to spend much money on speculation to develop new outlets.

Common High Brass

By R. S. PRATT
Metallurgical Dept.
Bridgeport Brass Co.
Bridgeport, Conn.

COPPER-ZINC ALLOYS ARE WELL known in general and there is much in the literature concerning them. There is, however, considerable confusion in many references as to the exact analysis, because many variations and types of alloys have been tested rather than concentrated work on a particular alloy.

Copper and zinc form ductile (alpha) solid solutions up to zinc 36%. With zinc over 36% a second solid solution (beta) is formed which is appreciably less ductile in cold working. The 66-34 alloy is made commercially with a copper content between 64.5 and 67.5% and therefore represents about the lowest possible copper content in those alloys which contain simply the ductile alpha solid solution.

Beta solid solution is never found in common high brass except in the cast condition, or in exceptional cases of severe overheating, or when the copper content runs as low as 65%. In the latter case the beta constituent is quite often present, particularly after hot working to eliminate the cast structure, but proper annealing treatment will remove it, and it is, therefore, customary to regard the common high brass alloy as one purely of the alpha solid solution, whose atomic space lattice conforms to the face centered cubic system.

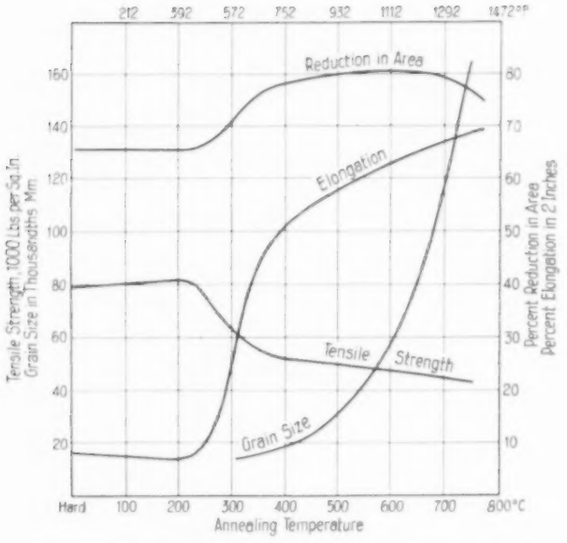
Endurance Limit — Data on endurance limits are available from various sources. Dr. McAdam reported an endurance limit for annealed high brass (15,000 lb. per sq.in.) slightly higher than for moderately cold worked material (13,000 to 17,000). Townsend and Greenall give 11,000 lb. per sq.in. as the endurance limit of annealed sheet brass and 13,000 to 15,000 lb. for rolled sheet brass.

Effect of Ingot Structure — High brass, as common with most metals, hardens on cold working, which makes it necessary to anneal before further cold working may be done. The temperature and time of annealing are of primary importance in controlling the properties.

When cast, the metal is fairly soft and ductile, but has a tensile strength and ductility appreciably lower than in the worked and annealed condition. The structure is not homogeneous, but contains some portions which are higher in zinc content than the average. Quite often the cast ingot or billet contains small amounts of porosity due to difficulties in the casting operation.

The cast metal is therefore annealed after casting to produce a homogeneous structure. It is then cold rolled or drawn. In some cases it is possible to make a cold working operation before annealing, which is advantageous in producing the homogenized structure. The cast metal may be hot worked if the impurities usually present are held to a minimum. When the metal hardens so that further cold rolling becomes impractical, it is then annealed. In annealing cold worked metal, softening or recrystallization occurs at a temperature ranging from 480 to 660° F. — the exact temperature depending on the amount of cold working prior to the annealing and the degree of annealing prior to the cold working operation.

Annealing Cold Worked Metal — The first figure shows how the strength of the cold worked metal is decreased to about 50,000 lb. per sq.in. by anealing in the above range. There is also a notable increase in elongation and reduction of area. Annealing at higher temperatures results in a relatively slight further decrease in the tensile strength and is also accompanied by a more noticeable increase in

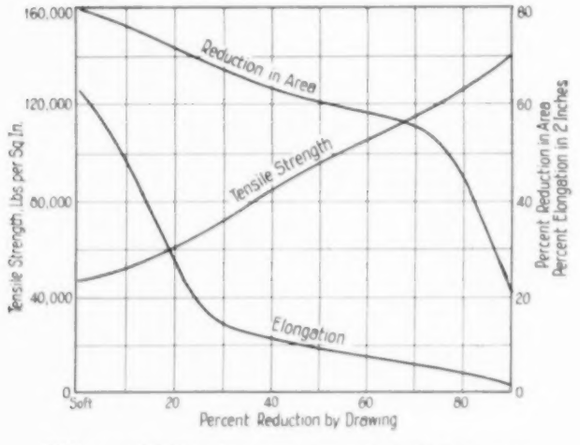

212 392 572 752 932 1112 1292 1472°F
Reduction in Area
Elongation
Tensile Strength
Grain Size
Tensile Strength, 1000 Lbs per Sq In.
Grain Size in Thousandths Mm
Percent Reduction in Area
Percent Elongation in 2 Inches
Hard
Annealing Temperature
100 200 300 400 500 600 700 800°C

Recrystallization of Cold Worked High Brass Commences at About 500° F. and the Metal Softens Rapidly as the Grain Size Increases

elongation. There is also an increase in grain size with increasing annealing temperature from the minimum which occurs immediately after complete recrystallization.

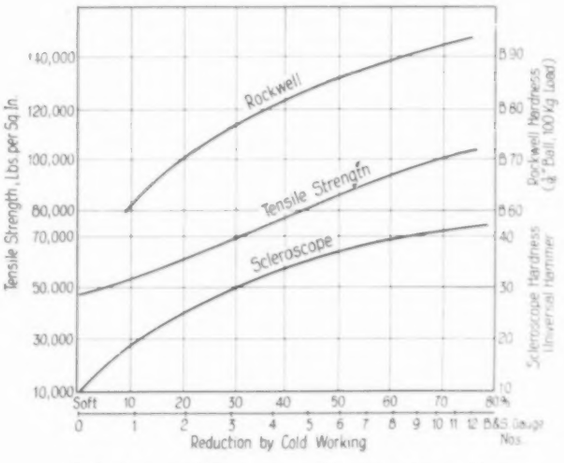
Considerable work has been done on the effect of *time* in annealing which would indicate that increasing the time will tend to soften the metal the same as does increasing temperature, although not to as marked a degree. This problem is brought out commercially in some types of electric annealing where a shorter time at higher temperatures takes the place of lower temperatures for much longer periods of time.

Effect of Cold Working — When the metal



When Cold Worked and Annealed High Brass Is Cold Worked the Tensile Strength and Reduction in Area Change Slowly and the Elongation in Tension Changes Rapidly

is fully annealed, it is ready for additional cold working and it is interesting to note the effect of various amounts of cold working. The second curve sheet shows that the first result is to increase the tensile strength of the material and very markedly decrease its elongation with a somewhat slighter decrease in reduction of area. The rate at which reduction of area decreases with the amount of drawing or cold rolling is an excellent comparative indication of the ability of the metal to withstand successive cold working operations without failure. Emphasis is laid on the term comparative, as the curves in the second figure might indicate that annealed high brass is fairly ductile and capable of withstanding repeated cold working operations up to a reduction of about 70%. As a matter of fact, this figure may or may not be attained,



Relation of Hardness to Tensile Strength Depends Upon the Amount of Cold Work Done Since the Last Anneal

as it depends upon the method of working and the suitability of the tools used.

Impurities — High brass is made in several grades. Lead and iron are the most common impurities introduced, but occasionally small amounts of tin get into the mixture through the use of scrap containing tin. The higher grade metals for eyelet brass and rivet wire use high grade zinc and the lead and iron contents are kept as low as 0.05% or even lower.

The effect of lead in quantities less than 0.10% does not seem to be apparent in the usual physical test data, but commercial experience would indicate that it is injurious if present in material to withstand the *(Cont. on page 50)*

Correspondence and Foreign Letters

TURIN, ITALY — There are obviously many reasons of a commercial and statistical nature for trying to establish a definition for alloy steel acceptable to interests in all countries, but many difficulties, logical and practical, present themselves.

Should we simply take into consideration the definition more generally accepted for plain steel, that is, "a malleable alloy of iron and iron carbide," we would reach the conclusion that every steel containing any quantity of another element (in addition to iron, carbon, and those strictly necessary in minimum amount to render the iron-carbon alloys malleable) should be considered as an alloy steel. But things are not so simple in every-day practice.

In the first place, it is practically impossible to ascertain the lowest proportions of certain elements which are strictly necessary to give malleability to an iron-carbon alloy, since those proportions depend in great measure on the manufacturing process. For instance, 0.25% manganese may be sufficient to give good malleability to a carbon steel, provided melting and refining operations have been carried out with special and even exceptional care and skill, while the same manganese content may be far too low when regular processes are followed. The same remark applies to the minimum silicon percentage in steel castings.

In the second place, small quantities of other elements besides those admitted to be "necessary" for a malleable iron-carbon alloy (often those very elements typical of alloy steels) may be present as impurities when common carbon steel is made. Such is the case, for example, for chromium or nickel contained in the scrap or remaining from a preceding alloy heat. Is it possible to fix exactly the highest limit to be admitted, in all cases, for such impurities?

Finally, it is often very difficult to establish the exact transition point between carbon steels and alloy steels when the elements normally contained in most steels (such as silicon, manganese, sulphur, phosphorus, copper) are gradually increased. Any such effort would quickly run afoul generally accepted commercial definitions. For example, it would be difficult to get producers or consumers of an 0.8% silicon structural steel to consider it an alloy steel. How, then, could a 0.9 to 1% silicon spring steel be an alloy steel? And, if the last is not an alloy steel, how about a 1.1% silicon steel? By steps of 0.1% the 2.5 to 3% silicon steels are finally reached which are certainly alloy steels, both technically and commercially.

From such considerations, it seems evident that under present conditions any purely technical or scientific definition for "alloy steel" would hardly be consistent with the general commercial and industrial practice, nor would it be accepted generally.

Composition Limits for Alloy Steel

Therefore, the best way to establish a satisfactory practical definition, would probably be to base it on generally adopted industrial and commercial practice. The first step toward this object should consist in a general survey of the customary usages in different countries.

Many known facts suggest that such a sur-

Correspondence and Foreign Letters

vey would show great differences between these usages. An example is supplied by the tariffs of different countries, where the most extraordinary and unexpected definitions of special and alloy steels may be found!

Aside from the customs and tariff specifications, the minimum percentages of various elements accepted by technologists in Italy as forming the lower boundary in the field of commercial alloy steels are approximately the following: Manganese 1.8%, silicon 1.5%, nickel 0.5%, chromium 0.3%, tungsten 0.3%, molybdenum 0.15%, vanadium 0.10%, aluminum 0.3%, copper 0.25%. High phosphorus and high sulphur carbon steels are generally not considered as alloy steels.

Of course, these limits vary somewhat with local practice, as could be demonstrated by a detailed discussion of the commercial reasons justifying the selection of each of the figures above mentioned.

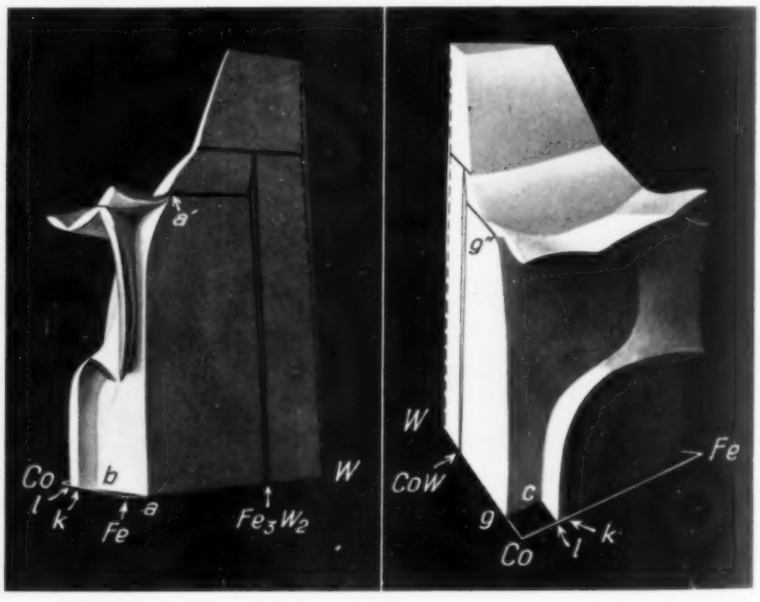
When minimum percentages of various elements are fixed for alloy steels, the definition can be greatly simplified and rendered completely objective by avoiding any mention of the reasons for which those elements have been added. In this field (as in every other) the investigation of human intentions is always very difficult, especially as applied to commercial problems.

FEDERICO GIOLITTI

Cutting Tools of Fe-Co-W

DORTMUND, GERMANY — In the February issue of METAL PROGRESS Zay Jeffries and W. P. Sykes describe a new material for cutting tools, a carbon-free iron-cobalt-tungsten alloy, which attains the necessary cutting hardness by precipitation hardening. It should be of interest to know that the same field has been investigated by the undersigned and his associates in the Research Laboratory of the Vereinigte Stahlwerke A.G. The first report of this work was published by me a little over a year ago in *Archiv für das Eisenhüttenwesen* for April, 1932.

In that paper the properties of the ternary alloys, particularly their capacity for precipitation hardening, are exhaustively treated. As a basis for this work we used the constitutional studies made in collaboration with W. Tonn and published in the same journal, Feb. 1, 1932.



Photographs of a Model of the Iron-Cobalt-Tungsten Structural System, Taken From Two Viewpoints

In the light of those studies Mr. Sykes's supposition that the information on these ternary systems is not yet complete is therefore in error.

In the following I shall attempt to repeat briefly the relationships which the above-mentioned papers explain at length.

The half-tone shows the three-dimensional

model of the iron-cobalt-tungsten system from two viewpoints. In the open space above the iron corner the alloy consists of alpha solid solution, and above the cobalt corner it is gamma solid solution. These two phases are separated by a two-phase territory in which the alpha and gamma solid solutions exist together in equilibrium, and which is bounded by the transformation curves of the two binary systems. Behind the two solubility curves of the alpha and gamma solid solutions belongs a delta mixed crystal range containing the two compounds Fe_2W_2 and CoW.

The range of compositions for heat treatable alloys can better be understood from the isotherms cut through the constitutional model at 20° and 1300° C. These are sketched in the adjoining diagrams wherein the fields of stability of the various solid solutions are shown. In the superposed diagram at the right the unhatched region to the right obviously represents compositions that contain alpha mixed crystals both at high and low temperatures; the unhatched region at the left covers compositions that have gamma mixed crystals at all temperatures, while the hatched intermediate region contains some gamma above 900° C. and some alpha at room temperature. These last mentioned alloys thus demonstrate the gamma-alpha transformation.

Precipitation hardening can take place in any of these fields except the area *g-c-l*, because the solubility of the tungsten-rich component δ varies with temperature. Maximum hardness is achieved after aging at a temperature characteristic of the constitution. Thus the maximum hardness value for the alpha alloys (open region at right) lies at 700° C., for the gamma alloys (open area at left) at 800°, and for the cross-hatched intermediate range at 600° C. It appears, therefore, that equilibrium is reached more quickly by precipitation through the gamma to alpha transformation. These observations were accurately checked and verified in the above-mentioned investigations by measurements of hardness, elongation, specific gravity, and magnetic and electric properties.

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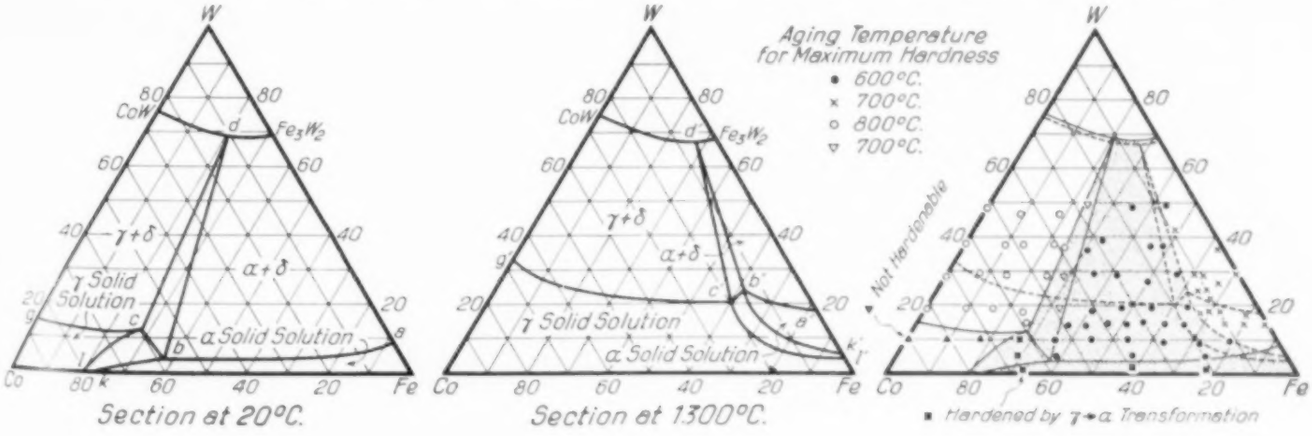
Alloys for cutting tools lie in the middle range of martensitic alloys, that is, those which have the $\gamma \rightarrow \alpha$ transformation. The maximum hardness increase is found at a content of about 30% cobalt and 15 to 20% tungsten. These alloys have proved especially good as cutting alloys, considerably surpassing cobalt high speed steel. Lathe tools of the two materials, working under identical conditions, had a cutting life of 152 min. and 34 min. respectively. The test log had a tensile strength of 135,000

Sections of Space Model at 20° C., at 1300° C., and the Two Superimposed. Hatched area shows alloys containing gamma phase at high temperature which tend to transform to alpha phase upon cooling

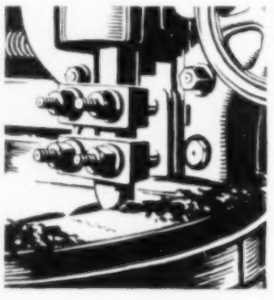


Correspondence and Foreign Letters

lb. per sq.in.; the feed was 0.057 in. per revolution; the depth of cut was 0.16 in. and the cutting speed 40 ft. per min.

Carbon-free alloys hardened by precipitation also have fundamental advantages over alloys hard as cast, as well as over high speed steel. First they are forgeable, while the hard metals can only be formed by casting and grinding. Furthermore, in contrast to high speed steel, they can be machined to size after quenching and before aging, thus avoiding oxidation and warping. Neither is there any possibility of decarburization during heat treatment. These considerations are especially important for tools having fine teeth or edges. The finished tool does not need to be exposed to high temperatures (around 1300° C.) in its treatment. Neutral or reducing atmospheres can readily be provided.

These facts indicate that substantial progress has been made over the former possibilities of tool manufacture. The undersigned therefore shares with Messrs. Jeffries and Sykes the conviction that the carbon-free, precipitation hardened, iron-cobalt-tungsten alloys will occupy an essential place in the field of cutting tools.



In this connection it should also be mentioned that we have also developed a carbon-free magnetic alloy, whose properties are attributed to precipitation hardening. It is an alpha solid solution in the field *a'-b'-k'*.

W. KÖSTER

NIAGARA FALLS, N. Y. — Mr. Bornstein's article on "High Strength Iron" in METAL PROGRESS for June contains a brief paragraph about titanium which I believe fails to do justice to the subject, even in the limited space available. It also contains what must be a typographical error: "Oxidizing and scavenging effects of titanium on cast iron have been reported" should, of course, read "Deoxidizing and . . . "

Titanium in Cast Iron

The present writer has prepared a brief paper for the current meeting of the American Foundrymen's Association, wherein it is shown that in reality the most important effect of titanium on cast iron is its refining action on the graphite flakes, or in foundry parlance "closing the grain."

Its influence in this way is stronger than that of other alloying elements for which the same effect is claimed, and results in an improvement in strength, *unless* too much is added, whereupon the graphitizating effect mentioned by Mr. Bornstein comes to the fore. This is easily shown not only by photomicrographs but in fractures, has been noticed by others, and is the chief reason for the use of titanium in gray iron in actual foundry practice at the present time.

Another and less important point regarding titanium that was not mentioned is that titanium is found in small amounts in practically all cast iron, and can be seen in its microstructure, but larger amounts of about 0.1% are generally necessary to give the good effects mentioned.

The best results in increasing the strength of cast iron, noted in my paper before the American Foundrymen's Association, were obtained with titanium, and chromium, and it was somewhat surprising to note that the iron alloyed in that way was no more difficult to machine than untreated iron and easier to machine than the more commonly used chromium-nickel irons or molybdenum irons. Introduction of about 0.10% titanium and 0.50% chromium increased the transverse and tensile strength of plain cast iron 10 to 20%.

GEORGE F. COMSTOCK
Metallurgist, Titanium Alloy Mfg. Co.

Correspondence and Foreign Letters

GROSNY, U.S.S.R. — My letter in June METAL PROGRESS described the present production of vanadium as a byproduct of the Kerch steel works in Crimea. The present notes cover a project recently authorized by the Soviet government for the annual treatment of 1,000,000 tons of vanadium-bearing titano-magnetite ore from a deposit of proven ore in the Kusa mining district in the Ural Mountains.

This ore body, containing about 7,500,000 tons of ore, has been known long before the War, but has never been mined in any large way because of its high titanium content. The analysis approximates 55 to 63% Fe, 16% TiO_2, 0.4% Cr_2O_3, and 0.65% V_2O_5; on the other hand, the ore is low in sulphur and phosphorus. By comparison with the Kerch ore, which contains only 0.15% V_2O_5, it will be seen that the Kusa deposit should be a better source of our much needed vanadium.

Of course, it has been the titanium content that has kept this ore from the market. It is the experience of the nearby Tagil iron works that the Kusa ore produces a viscous, refractory slag if used in any quantity sufficient to make a slag containing 30% TiO_2. Yet this figure must be approached if titanium oxide pigment is to be secured as a byproduct — and this is one of the objects of the present project.

New Sources of Vanadium

During a long series of trials, Prof. Britzke attempted to lower the melting point of the titaniferous slag by adding common salt to the furnace burden. Preliminary experiments indicated that a salt fusion caused the slag to melt at about 1500° F. into a quite liquid body.

Attempts in the blast furnace showed, however, that the salt charged as flux was mostly carried out the furnace top with the hot gases. Prof. Britzke now avoids this difficulty by producing "salty coke." He blends the salt with the fine coal before charging into the coke oven and gets a coke thoroughly impregnated with the salt.

Using this "salty coke" as blast furnace fuel has solved the problem of smelting the Kusa ore, at the same time producing a fusible slag containing up to 42% TiO_2. This has been proven at the Tagil works, where a blast furnace operating in the regular way was suddenly changed to a burden of Kusa titano-magnetite and salty coke. The campaign lasted 16 days, when the burden was switched back to normal. The coke consumption was not increased; in fact, no difficulties were encountered. The furnace operation was, if anything, more regular. No bad effects on furnace lining, down-take brickwork, or stove checkerwork due to the salt could be observed. On the other hand, the furnace top appeared to have acquired a thin layer of glaze.

During this 16-day trial run a high grade of pig iron was secured, which analyzed 0.60 to 0.80% vanadium. When this pig iron was blown to steel in a bessemer converter, from 80 to 85% of the vanadium passed into the slag. The latter analyzed 5.5 to 7.5% V_2O_5 and was treated as described in the last letter with a recovery approaching 95%. The bessemer process seems to be much better for recovering the vanadium. A basic open-hearth heat showed that about ¾ of the vanadium went into the slag, but only 16% of that was later recovered by the methods in use at Kerch. Another process (an oxidizing roast with soda and a leach with 0.5% caustic alkali solution) gave a 90% extraction on the open-hearth slag. The end point in any case is calcium vanadate, which is smelted to standard ferro-vanadium in an electric furnace. There is nothing new about this latter operation.

While the necessary development work is being pressed at the mine, interesting experiments have been put under way on the commercial recovery of "titanium white" from the blast furnace slags, and on the direct reduction of the Kusa ore with producer gas.

B. M. SUSLOV

Correspondence and Foreign Letters

Statistical Research in Metallurgy

SCHWEINFURT, GERMANY — About ten years ago Dr. K. Daeves proposed that statistical analysis be introduced as a new research method in the German iron and steel industry. Since then it has been an extremely successful basis for plant supervision, elimination of defects, and evaluation of research. Many industries have been able to improve both the quality of production and their economic conditions by its proper application.

The principles of statistical analysis were outlined in METAL PROGRESS, Sept., 1931, in an article on statistical control by Messrs. Hayes and Passano, who sketched the methods used to determine whether variations in an observation or in an observed quality were due to chance or to some controllable variable. In the latter case, of course, something can be done to promote uniformity.

Dr. Daeves' recent book on practical statistical research (Ueber praktische Grosszahlforschung, published by V.D.I.-Verlag, Berlin) discusses these methods for plant supervision and elimination of defects and should therefore warrant attention of many persons outside our country who can read German readily.

At the last scientific meeting of the Verein deutscher Eisenhüttenleute, Dr. Daeves again demonstrated the value of his method when discussing the cause and cure of sand splits (*Sandstellen*) in heavy forgings.

If one examines heavy forgings (the same thing applies to smaller ones), small porous spots, often containing manganese silicate slag particles, sometimes may be found just before the machining is finished. These are the so-called sand splits. *(Continued on page 60)*

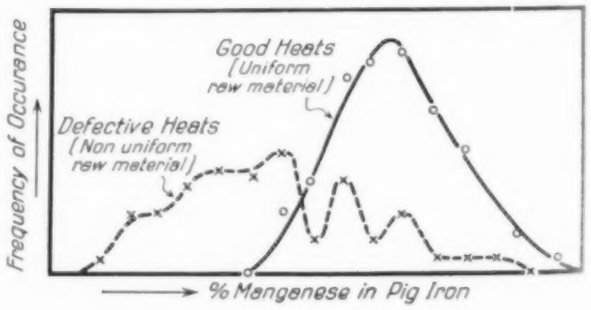
Porous Plastics Made by Use of Calcium Alloys

GLASGOW, SCOTLAND — The highly oxidizable character of the metal calcium has long been recognised, but it is doubtful if this property has ever been applied in industry. The following work has been performed experimentally, and it remains to be seen if it will become adopted commercially.

Certain refractory bodies require to be formed into a porous condition, and whilst cork and other materials are utilised for this purpose, they do not always accord the desired uniformity of product. With burned clay products the porosity is largely dependent upon the nature of the raw material itself. When cork or other carbonaceous matter is added to clay, the increase of porosity is seldom thoroughly satisfactory, although boiler insulation made thereof is used at the present time to some extent.

Attempts at introducing porosity in a measure which could be accurately controlled and thus provide a uniform product have been tried out on various materials. Amongst these might be mentioned cement, concrete, and different clay products. Most attention was at first focussed on increasing the small bubbles of gas formed in the mass, and this was later developed to introducing a means of control. The earlier endeavors were to increase the porosity by means of producing innumerable minute bubbles of gas in the plastic mass as a result of chemical reaction.

At the outset it is at once evident that any substances used for this purpose, and which



Influence of a Single Constituent in the Pig Iron Used in Making Two Groups of 50 Heats of Forging Steel; One Group Made Satisfactory Forgings; Sand Splits Occurred in the Other Group

"*It's Good to Hear Your* VOICE"

THIS very day the telephone will touch the lives of millions of people. To a modest home in the suburbs, it will carry words of love and comfort and the assurance that all is well. In another home, a housewife, busy with her work, will pause a little while to place her daily orders or answer a welcome call from a friend. To some one else, the ring of the telephone may mean good news about a position or a business transaction.

To have a telephone in your home is to hold your place in the world of people—to keep unbroken your contact with those whose help and friendship are so essential.

Individuals employ the telephone in many different ways. The busy, to save time. The friendly, to win more friendship. The lonely, to make contacts. The troubled, to find comfort and reassurance. The frightened, to call for aid. The gay, to share their gayety. It is through the medium of the telephone that thoughts become words and words become messengers between one human mind and another, defying space and time and all the elements that would interpose delays and doubts.

The value of the telephone can be measured only by measuring the activity of the people who use it and the diversity of life itself.

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will remain in the finished product whether fired or otherwise, must exert no harmful influence.

Consequently it was decided to try the metal aluminum as the most appropriate gas-producing medium. In preparing the wet material, addition of finely powdered aluminum evolved hydrogen as a result of its reaction with the water present. This reaction, however, is only a temporary one, and ceases when once the metallic particles have become covered with a coating of oxide. To meet this exigency, a little caustic soda was added to the water in the mixture. This caused the evolution of the gas to be slower, much more prolonged and regular.

Greater progress toward the desired end was made by using alloys principally composed of calcium, and although their cost was comparatively high, a very minute proportion was sufficient to furnish the desired porosity. Alloys were prepared of calcium and a smaller proportion of magnesium; the composition apparently has to be varied to suit the different refractory bodies to be treated, but the amount of alloy added seldom exceeds 0.1% of the mass to be treated.

A record is taken of the time occupied in increasing the volume to a pre-determined size with different materials.

No difficulty is experienced in producing a highly and uniformly porous mass by this means. So far the most difficulty has arisen as a result of the gas escaping too rapidly, and then the mass shrinks unduly on drying.

C. C. Downie

Correspondence and Foreign Letters

Influence of Basic Process on Ore Reserves

PARIS, France—Recently the "Société des Ingénieurs Civils de France" commemorated by a formal meeting the discovery of the basic processes for dephosphorizing steel. Sidney Gilchrist Thomas and Percy C. Gilchrist are the most notable names in connection with the converter operation, and Alexandre Pourcel's with the operations in the open hearth. It is seldom realized how this discovery revolutionized the metallurgy of iron in Europe by transforming some beds of phosphoric iron oxide into valuable commercial ore, more particularly those of the Lorraine district, and thus giving a prodigious extension to the available resources of the iron smelter.

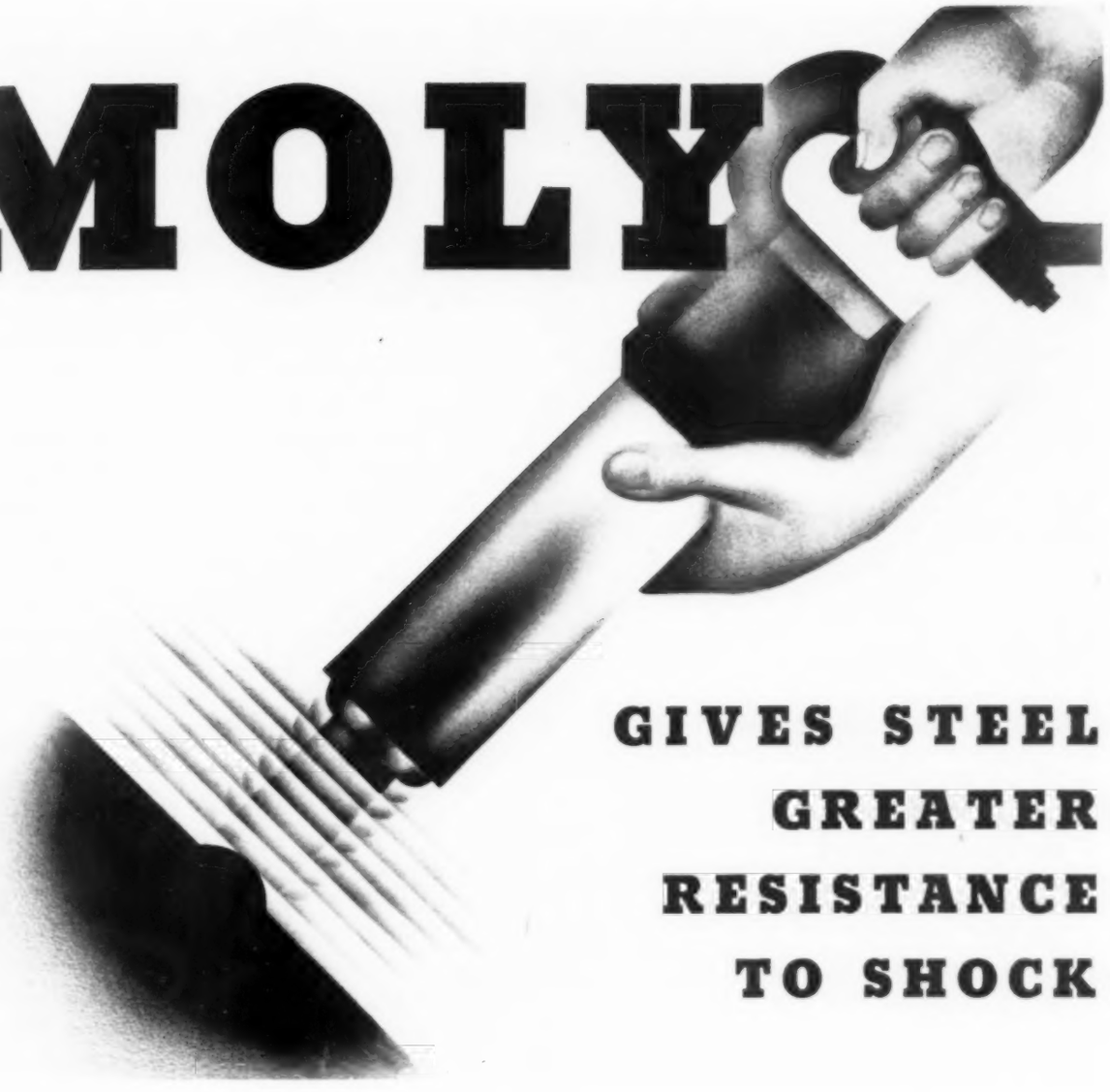
In France, for instance, 98% of manufactured steel is now obtained on basic linings, that is to say, about 69% of Thomas converter steel, 27% of basic Martin steel, and 2% of electric basic steel. Consequently, steel produced on acid linings represents only a very small proportion; acid open-hearth steel represents only 0.3% of the national production.

Other changes have also taken place in the manufacture of the quality steels. The electric furnace which does not require choice raw materials has been substituted for the crucible. In France the production of crucible steels has fallen from 24,000 metric tons in 1918 to 5000 tons in 1931, whereas in the same period the production of electric steel rose from 21,000 to 149,000 tons. The same trends may be observed in the World production of electric steel.

The mining of phosphorus ores made possible by the basic process of steel refining has become so intensive that the future of the Lorraine mining district must be anxiously studied. At the commemorative meeting M. Crussard stated some very interesting considerations. The proven reserves of France he estimated to contain 1.5 billion tons of iron. While this is one-fifth of the known reserves in the world, yet considering the annual production of 13 million tons of iron, these reserves of ours will be exhausted in 115 years. This period of time may be reduced to 80 by increased production.

A second disturbing condition exists: Two kinds of Lorraine ores must be distinguished, (*a*) the self-fluxing ore *(Cont. on page 54)*

MOLY



GIVES STEEL GREATER RESISTANCE TO SHOCK

WHERE plain carbon steel is not quite good enough and a highly alloyed steel is economically prohibitive, Molybdenum will greatly increase the strength of carbon steel (maintaining that increased strength at high temperatures) and give greater ductility and resistance to impact. Moly is the most economical alloy you can add to an existing alloy steel when additional qualities are required. In many steels the addition of Moly, with an increase in the manganese and other low-cost alloys, permits a material reduction in the expensive alloys.

Machinability is an outstanding characteristic of Moly steels. Cutting speed, even in an alloy steel notoriously difficult to machine, can be stepped up simply by adding Molybdenum — with an improvement in the metal's established characteristics.

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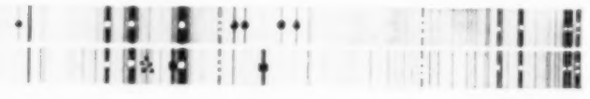
When the Product Goes Wrong—

Look to the raw materials for the answer!

Both spools illustrated above were made from a standard die cast alloy of the 93% zinc, 4% aluminum, 3% copper type but in one the tin was high, without sufficient magnesium to compensate. The resulting crystal growth caused the deformity which rendered the spool unusable.

In this case a small sample and one and one-half hours of time were necessary to make the spectrographic analysis. The wet method would have required several days of waiting and working with a 500 gram sample.

Modern alloys with their rigid limits of such elements as cadmium, magnesium, etc., in many cases cannot possibly be held to specifications by any means other than the sensitive, rapid spectrographic method.



A short section from a spectrographic plate of the two sprocket spools pictured above. The spool which failed gave the spectrogram at the top, note strong tin lines (marked with black circle). The good spool gave the spectrogram at the bottom. Note absence of tin and presence of magnesium, (marked with black square). Spectrography gives the entire analysis in one picture.

Spectrography warrants your careful investigation. Send for complete details.

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66-34 Brass

most severe cold working operations. Lead in quantities over 0.25% has been found to aid materially when it is desired to machine articles made of high brass. Its function is to break up the chips, making their removal much less difficult. As the lead content is increased, the cold working becomes more difficult, due to the decrease in percentage elongation and reduction of area. By compromising between the machining properties and ductility, it is possible to produce a number of valuable alloys merely by varying the lead content.

The effect of iron is much more noticeable. Amounts over 0.05% decrease the grain size and increase the tensile strength appreciably. Because of this, most specifications limit the iron content to that amount.

Uses — From the first two figures it may be seen that the properties which can be obtained in high brass cover a wide range. This accounts for the large number of uses to which it has been applied.

Large quantities of brass sheet are fabricated into various articles, for example, electrical fittings, flashlight parts, and automobile hardware. Many of the parts are ornamental in character. High brass tubing is used in various manufactured articles and considerable pipe is made of this alloy. Large amounts of high brass wire are used in the manufacture of screws and rivets and for various heading jobs of this type.

Corrosion — Much of the difficulty encountered in the use of high brass has been with the phenomenon known as "season cracking." Intercrystalline cracking in service (which is the same general action) occurs in several ways and is caused by a combination of corrosion and stress. The time element required to bring about failure is dependent on the severity of the corrosive action and the extent and intensity of the internal stress. Because of this, high brass that is to be exposed to the atmosphere is usually given a final annealing operation to relieve the internal stresses. If the corrosive

action is sufficiently severe, the external stresses acting upon a structural member are also likely to cause this type of failure even though the internal stresses have been relieved.

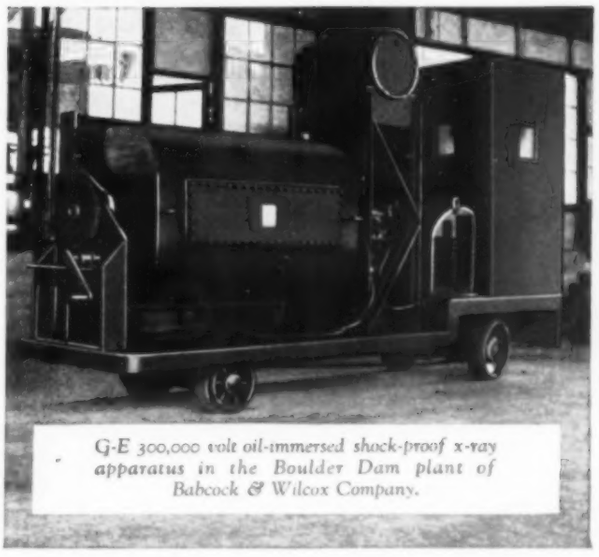
It is, therefore, inadvisable to use high brass where it is subjected to severe external stress and exposure to the atmosphere. Ammonia compounds and mercuric salts are particularly active agents in causing this type of failure.

Another difficulty encountered in the use of high brass is known as dezincification, a form of corrosion encountered when the metal is in contact with acids or with impure and salt-bearing water. The mechanism of the process was clearly described by Robert Worthington in last month's issue, page 22. Occasionally this action will occur locally and penetrate a water tube or pipe in a very short time. In most cases, however, where soft water is to be carried, high brass can be used without danger from dezincification.

Specifications, much used and developed by American Society for Testing Materials, B-36-27, are based on the tensile strength of the material. Hardness tests are much more convenient, but experience has shown that the Brinell test is satisfactory only for metal heavier than 0.080 in. Inasmuch as this represents only a small percentage of the amount of sheet which is made, some other means of testing is desirable. Considerable work has been done in developing limits based on the Rockwell hardness test. In the case of hard material below 0.020 in., the scleroscope test must be used. Here again, allowance must be made for the gage variations below 0.020 in. and it is advisable to base such specifications as may be necessary on the particular problem to be met. The third curve sheet gives an approximate relation between hardness and tensile strength of high brass cold worked various amounts.

In the case of soft or annealed material, the grain size has been found to be the best indication of ability of brass to withstand forming operations. It also gives an excellent indication of the type of surface obtainable after forming.

The question of how to order high brass for any particular fabricated article is somewhat complicated. When there is a doubt as to just what to order, it is wise to take the prob-



G-E 300,000 volt oil-immersed shock-proof x-ray apparatus in the Boulder Dam plant of Babcock & Wilcox Company.

World's Largest X-Ray Job Begun at Boulder Dam

DOWN within the Black Canyon of the Colorado River engineering history is in the making. Construction crews are burrowing in the man-made bowels of these volcanic mountainsides, installing the mammoth conduits and penstocks for Boulder Dam. Sections of plate-steel pipe up to 30 feet in diameter, 24 feet long, 2¾ inches thick and weighing about 150 tons, are being lowered from a cableway 600 feet above the landing stages and placed in position to form the 14,500 foot conduit system of this immense project.

High up on the rocky slopes, a mile from the canyon's rim, x-ray history is also being written. Here, in the Babcock & Wilcox fabricating plant, a General Electric 300,000 volt x-ray unit passes upon the soundness of every inch of more than 75 miles of fusion welds which will be required to form these conduit sections—the most gigantic x-ray task ever undertaken. This G-E x-ray unit, oil-immersed and shock-proof, is built to stand up under this gruelling use, producing consistently good radiographs, day in and day out, with ease, efficiency and speed, and with 100% electrical safety to operator and workmen.

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66-34 Brass

lem up with the manufacturer and obtain the benefit of his experience.

In general, articles requiring appreciable amounts of forming must be made from annealed (soft) brass. The question of the exact temper to be used is based on the amount of cold forming, the gage of the metal, and the surface required after forming. Many articles are required to withstand considerable forming without further annealing and must be in such condition after forming that they may be readily polished. The grain size in such cases must be kept as fine as possible consistent with the forming operations, and the latter must be closely controlled.

The balance between the temper of the material and the operation is a very delicate one, particularly in those cases where the forming operation will not allow ironing or smoothing the metal surface in the die. When the metal is to be given a number of draws and anneals, such as in producing a drawn shell, the grain may be somewhat coarser. Even then, however, the grain must not be so coarse as to produce a rough bottom on the cupped sheet, particularly if this is to be a part of the finished article. In some cases the surface appearance is of no importance and much deeper and more severe cupping operations may be performed on the sheet if it is produced with a coarse grain.

The Rockwell test is generally used for the control of hard metal, and here again the decision of the proper temper to be used should be based on a full knowledge of the problem. When forming or bending operations are only slight, the material must not be too hard. While "half-hard" temper is usually used for this, there are some instances where even lighter tempers are required and metal less than one number hard must be furnished. When used for spring purposes or plate work, the metal must be rolled harder. Thus, the exact hardness depends on the surface required and, in the case of the springs or clips, the amount of bending required.

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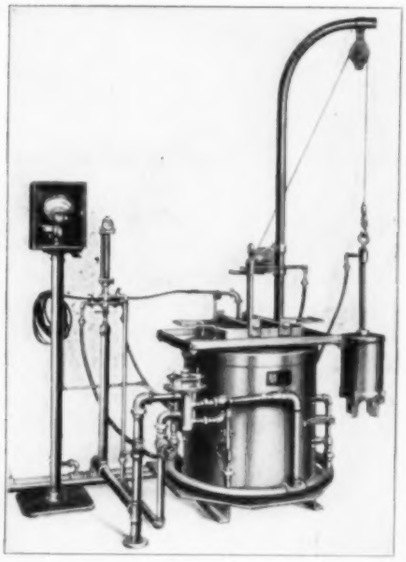

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Correspondence

and (*b*) siliceous ore, which can be smelted only when some limestone is added to the burden. Crussard estimated that only half of the metal in the French ores is contained in the first and most desirable class while the other half is in the siliceous ore. On the basis that a normal increase in production could exhaust all reserves in 80 years, the self-fluxing ore will be gone in 50 years if the present proportional consumption is maintained.

Therefore, in addition to a judicious use of these supplies, a readjustment of the production of these two kinds of ore to the relative importance of their reserves must be foreseen. Such changes involve a series of delicate measures in economics as well as difficult technical problems. Among the latter are the use of poor limestones containing some iron, the beneficiation of the ore before it is forwarded to the blast furnace, and the improvement of coke reactivity.

As a matter of fact, France's situation with regard to her iron ore reserves is not exceptional. The actual world reserves are about 7.5 billions of tons of metal contained in the oxide ores. In view of the record of the past 30 years, we may consider a normal annual production of 75 millions of tons of metal. Iron ore reserves may therefore last a century, even without allowing for a reasonable increase in production.

Thus, it may be thought that humanity has, in known reserves, what is necessary to supply itself during the average duration of a human life. Before this time is up it will be necessary to turn toward the potential iron deposits, that is to say, the ore bodies known to exist but whose economic importance has been at or near zero, either on account of geographic or geologic location, or on account of chemical composition and content of contaminating nonferrous minerals.

Entrance of these potential stores on the stage will not occur without seriously dislocating the present iron ore and steel industry.

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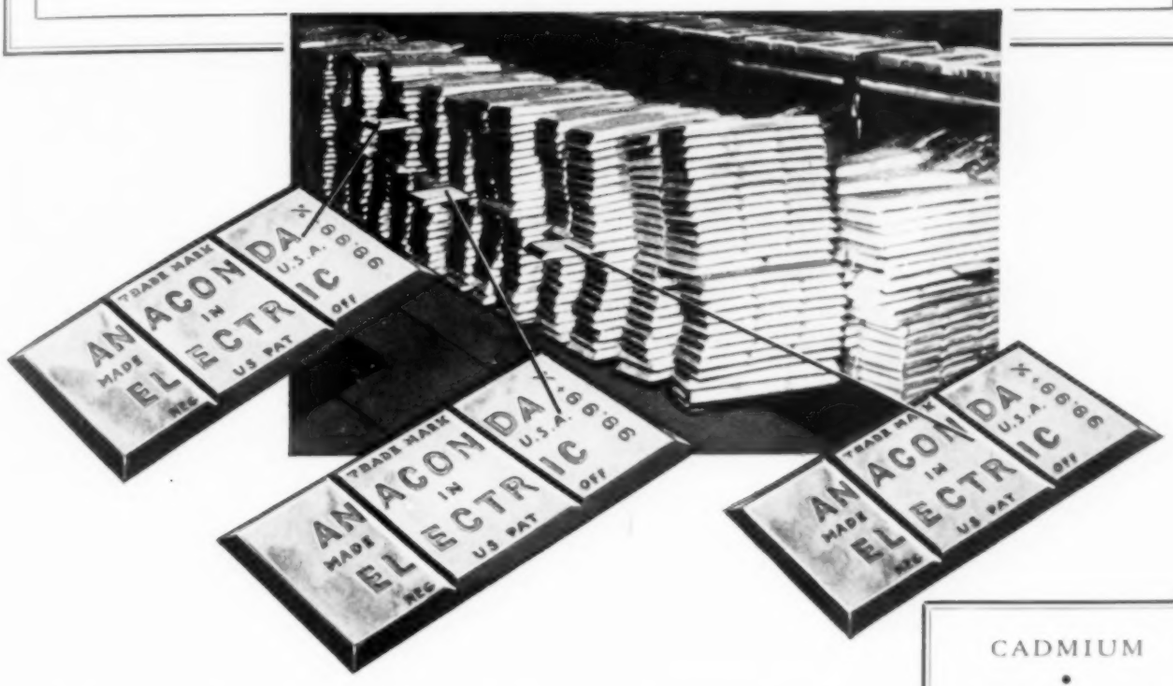

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Uses of Molybdenum

Climax Molybdenum Co. offers a new and useful 50-page booklet dealing with the benefits conferred by molybdenum as an alloying element in iron and steel. In orderly fashion engineering data are presented and made clear with numerous tables and illustrations. Bulletin Au-4.

New Zinc Coating

Wire which has been zinc coated by the new Bethanizing process is described in Bethlehem Steel Co.'s latest folder. This process produces a zinc coating which has proved to be more ductile, tighter, tougher, more uniform and purer. Coatings 3 times as heavy as formerly can be made. Bulletin Au-76.

Roll Grinding

Carborundum Co. has just published a 50-page booklet on roll grinding which may be considered a handbook of available information on this subject. Carefully written and amply illustrated, this treatise will undoubtedly be of real practical value. Bulletin Au-57.

Spectrography

The value of spectrographic analysis in manufacturing control is pointed out by Bausch & Lomb Optical Co. in an interesting booklet. This sensitive but rapid instrument is thoroughly explained, emphasis being laid on its practical application in industry. Bulletin Au-35.

Choosing Nickel Steel

International Nickel Co. has an ingenious chart to show at a glance the nickel alloy steel compositions and treatments needed to develop yield points in section sizes from 1 to 12 in. It is useful in selecting bars, shafting and forgings of simple shape. Bulletin Au-45.

Progress in Burners

The sermon in the new folder of Surface Combustion Corp. is that up-to-date burner equipment is an economy on any furnace and may perform some heating operation more economically or produce better quality without necessitating a new furnace. Bulletin Au-51.

New Foxboro Pyrometer

Foxboro Co. describes the new Foxboro potentiometer recording pyrometer in a recent bulletin. The outstanding features are a new design of balancing mechanism, ability to make from one to six records, a 12-in. chart, rapid recording cycle and a moisture-proof case. Bulletin Au-21.

Low Cost Recorder

Inexpensive dependability in measuring and recording temperature is the great asset of the new Leeds & Northrup round chart Micromax indicating recorder which brings the reliability and easy maintenance of the motor-driven null recorder to a new low cost. Bulletin Ap-46.

Globar Elements

Globar electrical heating units and a variety of accessories for their operation have been catalogued by Globar Corp. A list of the standard industrial type heating elements and a coordinated list of terminal mountings and accessories is included. Bulletin N-25.

Pickling Inhibitors

A pamphlet describing the nature and use of Grasselli Inhibitors is available to all those interested in the pickling of steel. It not only describes the merits of these inhibitors, but it gives a table of suggested inhibitor strengths to be used in the pickling of the various grades of steel. Bulletin Ap-95.

Stainless Sheets

A very useful booklet describing the stainless steel sheets and light plates made by American Sheet & Tin Plate Co. gives recommendations for fabrication and a description of finishes and analyses available. Bulletin Ap-96.

"Vee-less" Arc Welds

New literature covering a very recent development in arc welding has been prepared by Metal & Thermit Corp. Known as Murex Straight Gap welding, the new process eliminates grooving or "veeing" the edges even of heavy plates. Welding time is halved and other savings are effected, it is claimed. Bulletin My-64.

Quenching Handbook

E. F. Houghton & Co. have published an excellent 80-page handbook on the subject of quenching. More than 30 charts and photomicrographs help tell the story. A copy will be sent free to those who request it. Bulletin JI-38.

X-Rays in Industry

General Electric X-Ray Corp. has available a profusely illustrated brochure entitled "Industrial Application of the X-Ray," which gives the complete story of the field of application of this modern inspection tool. Valuable information is presented. Bulletin Ma-6.

2 Everdur Booklets

Two recent publications of American Brass Co. discuss Everdur, the high strength, corrosion resisting copper alloy. One covers its phys-

ical properties and resistance to corrosion, the other tells how to weld it. Either or both will be sent. Bulletins Jl-89a and Jl-89b.

Nitriding Facts

Information on possible new applications of Nitralloy and the nitriding process in view of recent developments may be obtained from Ludlum Steel Co. New economies in production and a better product may now be obtained. Bulletin Jn-94.

Furnace Heat Transfer

The practical application of the coefficient of heat transfer from furnaces to material is emphasized in a new folder of Electric Furnace Co. The folder is a reprint of two recently published technical papers which contain much valuable information for operators of electric or fuel fired furnaces. Bulletin Jn-30.

To Prevent Rust

The well known rust preventive, No-Ox-Id, is now available from Dearborn Chemical Co. as a foundation for paint. It is available in the colors red, gray or black. A booklet explains how maximum resistance to corrosion can be obtained. Bulletin Ju-36.

Maintenance Welding

This interesting booklet describes the use of the oxyacetylene process in the reclamation of broken and worn machine parts, alteration, fabrication and installation of equipment. Such equipment as piping, tanks, machine elements, engine and pump parts and conveying systems is covered in the 16-page illustrated booklet of Linde Air Products Co. Bulletin Jl-63.

Scleroscopes

The model D standard recording scleroscope is described and illustrated in a recent publication of Shore Instrument Co. The theory and practice of hardness testing with this portable machine as described in this bulletin reveal a fund of valuable facts. Bulletin S-33.

Fatigue Testing

That much discussed topic—fatigue testing—is covered in a publication of Thompson Grinder Co. Interesting data on fatigue of metals and a description of the rotating beam type of fatigue testing machine are presented. Bulletin D-23.

Binocular Microscope

The new series of Leitz binocular microscopes yield such an exceptionally large field that at low or medium magnifications a large object can be completely examined without moving the specimen. A pronounced stereoscopic effect is an advantage in metallographic examination. An illustrated folder gives full details. Bulletin Jl-47.

New Way to Fight Rust

A new plating process for protecting steel against atmospheric corrosion is described in detail in a handbook entitled "Duozinc" issued by R. & H. Chemicals Dept. of E. I. du Pont de Nemours & Co. Besides a description of the process, the handbook gives detailed information on the most efficient electrochemical methods of curbing corrosion. Bulletin Jl-29.

Resistance Wires

Every user of electric furnaces will be interested in a new 40-page booklet prepared by Hoskins Manufacturing Co., to present data on nickel-chromium wire for electrical resistance use. A valuable feature is a new table of temperature emf. values on Chromel-Alumel thermocouples as established by the Bureau of Standards. Bulletin Jn24.

Quicker Heat Treating

Driver-Harris Co. discusses Nichrome sheet containers for heat treating in an illustrated folder which honestly states that while for certain purposes sheet containers cannot be used economically, there are a multitude of installations where their advantages of lightness and quicker heating can be fully utilized. Bulletin Jl-19.

New Type Furnace

A new bell-type retort furnace made by American Gas Furnace Co. can be used in quick succession for carburizing, nitriding, bright annealing in gas atmospheres, or for hardening, normalizing, tempering or annealing. It is an ideal heat treating tool where production is widely varied in character. Bulletin Jn-11.

3 Handy Charts

Brown Instrument Co. has printed three handy tables on durable cardboard for use in the heat treating department or laboratory: A conversion table for the Fahrenheit and Centigrade scales, a table of melting points of chemical elements and a heat color chart showing actual colors from 900° to 2200° F. Bulletin Jn-3.

Cast Vanadium Steel

Jerome Strauss and George L. Norris have written a technical booklet for Vanadium Corp. of America describing the properties developed by steel castings containing various percentages of vanadium. The information given is complete and authoritative. Bulletin S-27.

Heat Resisting Alloys

Authoritative information on alloy castings, especially the chromium-nickel and straight chromium alloys manufactured by General Alloys Co. to resist corrosion and high temperatures, is contained in one of that company's publications. Bulletin D-17.

Melting Aluminum

Aluminum and white metal alloys are easily and efficiently melted in the new model AT pot furnaces made by American Electric Furnace Co. New design features make for accurate temperature control, freedom from contamination of the melt and easy pouring. A complete description is given in Bulletin Jn-2.

High Cr Cast Iron

A pamphlet describing foundry production of cast irons containing from 15 to 30% of chromium has been issued by Electro Metallurgical Co. These cast irons do not grow or scale after repeated heatings and are excellent for high temperature work. Bulletin Ma-16.

Turbo Compressors

A series of three bulletins is available from Spencer Turbine Co. describing their Turbo Compressors for oil and gas fired equipment and foundry cupolas. Sizes range from 100 to 2,000 cu. ft., 1 to 300 h. p., 8 oz. to 5 lbs. Bulletin Fe-70.

Welding Stainless

An unusual amount of practical data is contained in a fine booklet just put out by Republic Steel Corp. which gives recommendations for welding the several Enduro stainless alloys. Generously illustrated. Bulletin Jn-8.

METAL PROGRESS,
7016 Euclid Ave., Cleveland.

Please have sent to me without charge the following literature as described in the August issue. (Please order by number.)

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NO-OX-ID

IRON + OX = RUST

TRADE MARK

The Original Rust Preventive

THE REAL TEST IN RUST PREVENTION

Why NO-OX-ID Has So Many Staunch Friends

After the last argument is weighed, after the last square foot is coated, then begins the long vigil that actually tells the tale. The four divergent reports here quoted project a picture of NO-OX-ID, striking in severity of service and in consistent effectiveness of rust prevention:

TANK—10 YEARS

Dearborn Representative, F. C. Gibbs, reports: "Coated 75,000 gallon tank about ten years ago with NO-OX-ID 'A Special'. Touch it up every two years. In fine condition and do not have to clean it as there is no rust."

COILS—9 YEARS

Dearborn Representative, W. N. Malcolm, reports: "Mr. D—— showed me coils in one of his storage rooms that are now in perfect condition after nine years' use of NO-OX-ID. These coils were very badly corroded when the NO-OX-ID 'A Special' was first applied."

BARGES—5 YEARS

Dearborn Representative, Z. D. Scott, reports: "Mr. C—— told me that he recently was ordered to inspect the barges which were built about five years ago and the inside coated with NO-OX-ID 'A Special'. Said that they are in as good condition as when built. He is using NO-OX-ID generally around the yard both on floating plant and also the locks. He stated that they are going to take the big lock gates out this coming winter, and he is going to clean them down and use nothing but NO-OX-ID."

PIPE LINE—7 YEARS

Dearborn Representative, I. L. Yetman, reports: "Inspected 6 inch gas line coated with NO-OX-ID 'A Special' and NO-OX-ID-IZED Brown Wrapper seven years ago. Inspected four places. The Wrapper and NO-OX-ID were intact and the pipe was in perfect condition. This is hard clay soil."

These reports mark inspection periods only—not a completed service. The NO-OX-ID is still "working" and will be for years to come on these and thousands of additional installations equally interesting.

This remarkably long service, plus ease of application and reasonable cost, has won a general acceptance for NO-OX-ID among men who have rust problems of any sort. Inquiries invited.

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310 S. Michigan Ave., Chicago 205 E. 42nd St., New York

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Trade Mark Registered

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WITHOUT QUALITY COMPETITION

HEAT AND CORROSION RESISTANT ALLOY CASTINGS

FROM OUNCES TO TONS

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GENERAL ALLOYS COMPANY

BOSTON - CHAMPAIGN

Convenience in HARDNESS TESTING

The MONOTRON

Makes for **SPEED, ECONOMY, ACCURACY**

The MONOTRON has now come into general use by discriminating establishments because:

A. It has the required Adaptability and convenience in operation upon which speedy and satisfactory service depends.

B. Two Dials show more than any one Dial tester, solving problem of application to all known materials of any hardness.

(Not Most Expensive Machine to Install.)

For additional information see our Bulletins M-3, M-5, also Bulletin M-7, giving list of satisfied users, sent free.

For a Good Single Dial Tester We Offer

The SCLEROSCOPE

(Latest Improved)

Quick, accurate, more popular than ever, it has the only simplified (Centigrade) scale which is understood and quoted the world over. The only tester that is 100% portable, and operative on work of unlimited size. Accurate conversions to Brinell.

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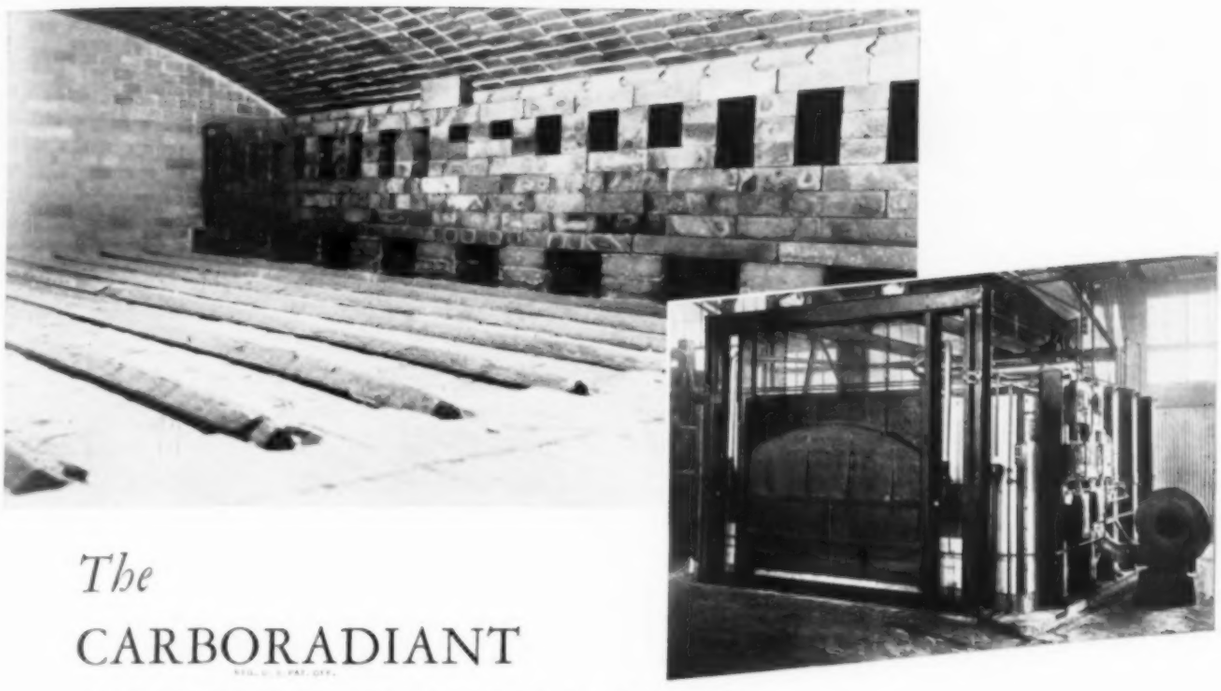

The

CARBORADIANT COMBUSTION CHAMBER

gave them the Atmosphere ideally suited to BILLET HEATING

THE Electric Furnace Company of Salem, Ohio, designed and built for a mid-western plant, an oil-fired hearth type furnace for heating stainless steel billets and equipped it with "Carboradiant" combustion chambers.

These chambers, built of "Carbofrax" shapes, together with fuel oil-firing, produce "a soft atmosphere ideally suited to this class of work".

The "Carboradiant" chambers are primary combustion chambers into which the fuel is fired and from which combustion gasses are discharged into the furnace proper.

Rapid and intimate mixing of fuel and air in contact with incandescent refractory surfaces promotes efficient burning of fuel.

The radiant heating element fired by single burner is easily operated at uniform temperature.

And "Carbofrax"—the Carborundum Brand Silicon Carbide Refractory—gives a refractory structure capable of withstanding highest temperatures and flame impingement.

"CARBOFRAX"

REG. U. S. PAT. OFF.

The Carborundum Brand Silicon Carbide Refractory

BRICK · TILE · MUFFLES · SHAPES · CEMENTS

THE CARBORUNDUM COMPANY (REFRACTORY DIVISION) PERTH AMBOY, N. J.

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AMERICAN SHEET AND TIN PLATE COMPANY, Pittsburgh, Pa.
SUBSIDIARY OF UNITED STATES STEEL CORPORATION

Correspondence

(Continued from page 46)

Such a small defect in the material, often visible only under a magnifying glass, will be sufficient to spoil a large piece, especially if it occurs in a critical place. Such spots occur most frequently in multi-throw crankshafts where the inner zone of the original ingot is laid bare. However, these defective spots are also found a small distance below the surface, and can be observed on shafts, ball bearing rings, and like parts. Everyone knows how unwelcome such defects are, with their accompanying loss of material, labor, and time, especially when they appear on a finished piece.

Dr. Daeves decided to investigate the origin of such failures by evaluation with statistical methods, because while exhaustive chemical and metallographical tests reveal and identify the nature of the defect, they do not indicate its origin. However, the origin and expedients for prevention are, of course, the most important things to know.

He was led to the conclusion that the type of pig iron, and further the refining process and the natural degree of fluidity in the steel bath had a close relationship to the occurrence of sand splits. The reaction between manganese and oxygen occurring during the steel refining also affects the refractory material of the hearth and ladle, and causes the formation of these "*Sandstellen*" or slag inclusions. On page 46 is one of the curves he presented, showing the influence of manganese content of the pig iron on good and defective heats of forging steel. It shows that in a group of sound heats the manganese in the original pig iron varies within definite limits according to chance (the frequency curve is the same as the probability curve). In the defective heats, however, the manganese content showed no such constancy. From such curves as this Dr. Daeves concluded that uniformity in the raw materials from which the steel was made was of utmost importance in the avoidance of forging defects such as the one under discussion.

HANS DIERGARTEN